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Catalog of Existing Small Tools for Surface Preparation and Support Equipment for Blasters and Painters

U.S. Department of Commerce
Maritime Administration
in cooperation with
Avondale Shipyards Inc.
New Orleans, Louisiana

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FOREWORD

This research project was performed under the National Shipbuilding Research Program. The project as part of this program is a cooperative, cost shared effort between the Maritime Administration and Avondale Shipyards, Inc., a subsidiary of Ogden Corporation. The objective of the program is improved productivity and therefore reduced shipbuilding costs to meet the lower Construction Differential Subsidy rate goals of the Merchant Marine Act of 1970.

The studies have been undertaken with this goal in mind and have followed closely the project outline approved by the Society of Naval Architects and Marine Engineers (SNAME) Ship Production Committee.

Mr. John Peart and Mr. H. D. Unthank, Avondale Shipyards, Inc., have served as Pro-

We wish to acknowledge the guidance provided by the 023-1 Surface Preparation Coating Committee of SNAME, Mr. C.J. Starkenberg, Chairman, Avondale Shipyards, Inc., in the selection of topics and technical critique of contents and format.

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EXECUTIVE SUMMARY

The objective of this project has been to provide supervisors of shipyard surface preparation and coating operators with a catalog of the small tools and support equipment used by blasters and painters. The prime criteria for format development being easy reference and understanding of the data presented.

The catalog contains equipment description, pictures, suppliers, recommended applications, description of surface obtained and equipment limitations. Additionally, the principles of efficient application of the equipment was stressed.

Emphasis was placed on the evaluation of equipment and methods of surface preparation that may be used for shipyard repair of painted surfaces.

The evaluation of equipment surveyed was made on the basis of meeting safety standards, effectiveness, and comfort of the workman.

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CONCLUSIONS

1. CONCLUSIONS

1.1 Cost Savings in Operations

The prime objective throughout the survey and the compilation of the catalog was the identification of areas in which surface preparation and coating cost savings can be realized. Equipment requirements and operational procedures were analyzed with this objective.

Results of the analysis led to the conclusion that increased productivity can be achieved through improved operational planning and greater understanding of the principles of efficient operation by first-line supervisors and operators, particularly in the area of abrasive blasting. While the majority of the tools required for efficient operations are available and in use in most yards, these tools are not always used effectively.

Surface preparation and coating has traditionally been one of the final scheduled operations in ship completion. Coating at the modular stage has partially relieved the problems inherent in this situation, but it has created others. Final finishing is still dependent on work schedules for the other crafts involved. In addition, coating in the modular stage results in a high percentage of rework, necessitated by coating damage due to burning and to chipping from dropped tools and metal scaffolding. Because these problems place an inordinate amount of deadline pressure on the paint department, adoption of a brute force philosophy is often the result. The principles of efficient planning and operation are often forgotten, and the final outcome is poor productivity.

Adherence to the principles of efficient planning and operation must be insured, however, if cost savings are to be achieved. Given proper adherence to these principles, the magnitude of the savings realized by companies both large and small will depend only on the size of the operation.

1.2 Surface Preparation and Coating

Cost reductions can be achieved in surface preparation and coating operations given (1) adequate understanding and implementation of the basic principles of efficient abrasive blasting and painting and (2) adequate preventive maintenance methods.

1.2.1 BASIC REQUIREMENTS OF EFFICIENT ABRASIVE BLASTING

The project found evidence of a lack of understanding of these requirements and of negligence in their implementation. The following checklist can be used by operators and supervisors as a starting point for determining if the yard's abrasive blasting facility is operating at full efficiency.

A. Do you have 90- 100 psi air pressure at your blasting nozzles when all stations are operational? When was the last time that these pressures were checked with a needle gauge? Do you know whether it may be possible to increase the nozzle pressures, resulting in higher blasting rates without expensive capital investment?

B. Are you using venturi nozzles? When were they last inspected for wear and damage? Have you seen an operator bang an expensive refractory-lined venturi nozzle against a bulkhead to get it unclogged? Have you ever seen an operator using a piece of steel pipe for sweeping or blasting?

C. Do you have any downtime due to clogged nozzles or machines? Do you have moisture traps on your machines? What is the moisture content of the air when it leaves compressor hoses? How. often do you blow your distribution lines?

D. What is your average replacement life on hoses and nozzles? If that rate is high, why is this so? What is your maintenance cost on blasting equipment? What is the failure mode that recurs most often?

Answers, or a lack of answers, to these questions may reveal abrasive blasting costs which are higher than necessary. Section 3 of this catalog, "Abrasive Blasting," provides some basic information on the principles of an efficient blasting operation. An education program for supervisors and, perhaps, for operators may be required, however, to insure effective implementation of these principles.

1.2.2 PREVENTIVE MAINTENANCE

The high cost of painting equipment and accessories makes it mandatory that operators have the knowledge and take the time required to keep equipment clean and in good working condition. If catalyzed coatings are allowed to cure inside the equipment, they will abrade the airless pump seals, making the pumps inoperative within a short time. Operators must be aware of

the pot lives of these materials at their temperatures of application.

The project survey determined that maintenance costs for this type of equipment are excessive. Implementation of certain preventive maintenance procedures will isolate and eliminate the conditions which create the need for high maintenance expenditures. For example, records should be maintained on failure modes whenever pumps are reworked and whenever hose failures are discovered. If kept on a regular basis, these records will soon reveal whether problems are caused by operator practices or unreliable equipment.

While some types of equipment may be more reliable than others, the survey was unable to make this determination because of the lack of documented data.

1.3 New Processes and Equipment

The survey identified two areas of new development which show great promise for increasing productivity: (1) closed-cycle blasting and automated painting of ship exteriors and (2) high-pressure, low-volume abrasive blasting.

Closed-cycle blast heads and automated paint heads are now available, but they have not been mated with a handling system which is capable of efficiently covering the contour areas of hulls. Newly developed handling systems, however, offer promise in solving this problem, with cost savings in both new construction and repair as the final result.

High-pressure, low-volume abrasive blasting is being used in Europe, and interest is being shown by abrasive producers in the United States. The process is ideal for coating tanks after launching, and it has the cost advantages of high blast rates and lower abrasive removal costs. Coating repair costs can also be greatly reduced.

The coating of tanks after launching by a high-pressure, low-volume process requires capital investments in ventilation and dehumidification equipment, and the curing problems associated with catalyzed coating at temperatures below 50° F. remain. Equipment and procedures are available, however, for raising substrate temperatures to 10° C. above ambient water temperatures. In addition, urethane epoxy tank coatings are being developed which can cure at near-freezing temperatures.

1.4 Research and Development Requirements

Several areas in which cooperative development efforts by the shipbuilding industry and the Maritime Administration could result in meaningful cost savings have been identified. Instructional programs in surface preparation and coating for supervisors and/or operators are needed. These programs should stress the principles of efficient abrasive blasting and coating. In addition, a documented maintenance program should be formulated, to include cost identification and control.

Procedures developed for these programs should be easily adaptable by yards to their. actual operations. Visual aids should be prepared to demonstrate the principles involved. (Equipment manufacturers may be willing to share the costs of this effort.) Arrangements for presenting training programs to receptive yards must be made when formulation of these programs is completed.

SECTION 2
ABRASIVE TOOLS

2. ABRASIVE TOOLS

2.1 General Findings

Because air-powered abrasive tools are the type used by most yards, they will be the major focus of discussion in this section. Some yards do use electric abrasive tools but are switching, or planning to switch, to air power for most of their surface preparation work. A 90 - 100 psi air power source is required for operation of these tools.

2.2 Air Supply

Regardless of how well an air tool is designed, its length of service depends almost exclusively on the conditions of the air which supplies it. Most air tools will give reasonable service if supplied with clean, dry and well-lubricated air. However, tools operated with excessive moisture or solid contaminants in the system will show less production, poor performance, greater downtime and a notable increase in maintenance cost. A checklist of the complete air system should be used periodically to insure maximum productivity from air tools.

2.2.1 DEHUMIDIFICATION

All compressor banks should have an efficient dehumidification system, whether desiccant or refrigerant, to remove moisture from the compressed air. The system must be more efficient as the length of the air main increases.

In special applications, such as pressure testing of cryogenic piping, the dryness of the air becomes extremely critical. For these applications, a dew point of -22° F. is required.

2.2.2 FILTERS

Most available filters contain a tiny screw which prevents the passage of pipe scale, rust, dirt and other particles. They also employ a moisture separator which traps the moisture. This feature minimizes the clogging of air screens and decreases the possibility of rusting, misting or freezing. It also preserves accurate surface finishes and close clearance.

2.2.3 OILERS

While a lubricant is necessary for tool operation and life, its deposit on surfaces to be painted is fatal. A periodic, careful inspection of the in-line oiler and tools must be made to insure that the proper amount of oil is dispensed.

Fluctuations in line pressure, due to the starting and stopping of tools, is one cause of excess oil flow. To minimize this problem, the oiler should be installed as near to the tool as possible. Oilers are also particularly vulnerable to foreign matter contamination. The installation of a filter upstream to the oiler will eliminate this problem.

If tools are manually lubricated, care should be taken that oil is not used in excess.

2.2.4 PRESSURE

Air-powered abrasive tools must be operated at designated air pressure (90 - 100 psi) to develop required speed and power. Most shipyards in the United States have air supplies which are within this range. Nevertheless, while pressure at the air main may be within the required range, a meaningful drop in pressure will occur if long lengths of small inside-diameter hose are used from the main to the tool. This drop is due to the internal friction of the hose.

2.2.4.1 Pressure Loss

Figure 2.1 shows the amount of pressure lost in hoses connected to pneumatic tools.

2.2.4.2 Air Regulators

If a yard's air pressures are in excess of 100 psi or if lower pressure tools, such as air wrenches, are used, pressure regulators are required. This controlled air pressure will enable tools to operate smoothly and consistently. It will keep tools from overspeeding and protect hoses and instruments from damage.

2.2.4.3 Accessory Description

Figure 2.2 shows typical air supply accessories, and Figure 2.3 illustrates a recommended scheme for arranging air piping and tool stations.

2.2.5 ADVANTAGES OF AIR TOOLS OVER ELECTRICALLY POWERED TOOLS

Listed below are some advantages of air-powered abrasive tools over electric tools:

1. More power per pound. Air-powered abrasive tools are light, small and easy to handle. They offer greater productivity and cause less operator fatigue.
2. No overheating.
3. Low maintenance requirements. Air-powered tools will not suddenly burn out because of shorting due to the accumulation of metallic dust in the motor. When problems occur with air tools, a gradual loss of power results. However, the replacement of inexpensive rotor blades will usually restore original power.

Pulsating Flow

Size of Hose	Gauge Pressure at Line	Cubic Feet Free Air Per Min. Passing Through 50' Lengths of Hose													
		20	30	40	50	60	70	80	90	100	110	120	130	140	150
		Loss of pressure in lbs. per sq. in.-5O' hose length													
½" with couplings at Each End	50	1.8	5.0	10.1	18.1										
	60	1.3	4.0	8.4	14.8	23.4									
	70	1.0	3.4	7.0	12.4	20.0	28.4								
	80	.9	2.8	6.0	10.8	17.4	25.2	34.6							
	90	.8	2.4	5.4	9.5	14.8	22.0	30.5	41.0						
	100	.7	2.3	4.8	8.4	13.3	19.3	27.2	36.6						
	110	.6	2.0	4.3	7.6	12.0	17.6	24.6	33.3	44.5					
¾" with couplings at Each End	50	.4	.8	1.5	2.4	3.5	4.4	6.5	8.5	11.4	14.2				
	60	.3	.6	1.2	1.9	2.8	3.8	5.2	6.8	8.6	11.2				
	70	.2	.5	.9	1.5	2.3	3.2	4.2	5.5	7.0	8.8	11.0			
	80	.2	.5	.8	1.3	1.9	2.8	3.6	4.7	5.8	7.2	8.8	10.6		
	90	.2	.4	.7	1.1	1.6	2.3	3.1	4.0	5.0	6.2	7.5	9.0		
	100	.2	.4	.6	1.0	1.4	2.0	2.7	3.5	4.4	5.4	6.6	7.9	9.4	11.1
	110	.1	.3	.5	.9	1.3	1.8	2.4	3.1	3.9	4.9	5.9	7.1	8.4	9.9
1" with couplings at Each End	50	.1	.2	.3	.5	.8	1.1	1.5	2.0	2.6	3.5	4.8	7.0		
	60	.1	.2	.3	.4	.6	.8	1.2	1.5	2.0	2.6	3.3	4.2	5.5	7.2
	70		.1	.2	.4	.5	.7	1.0	1.3	1.6	2.0	2.5	3.1	3.8	4.7
	80		.1	.2	.3	.5	.7	.8	1.1	1.4	1.7	2.0	2.4	2.7	3.5
	90		.1	.2	.3	.4	.6	.7	.9	1.2	1.4	1.7	2.0	2.4	2.8
	100		.1	.2	.2	.4	.5	.6	.8	1.0	1.2	1.5	1.8	2.1	2.4
	110		.1	.2	.2	.3	.4	.6	.7	.9	1.1	1.3	1.5	1.8	2.1
1¼" with couplings at Each End	50			.1	.2	.2	.3	.4	.5	.7	1.1				
	60				.1	.2	.3	.3	.5	.6	.8	1.0	1.2	1.5	
	70				.1	.2	.2	.3	.4	.4	.5	.7	.8	1.0	1.3
	80					.1	.2	.2	.3	.4	.5	.6	.7	.8	1.0
	90					.1	.2	.2	.3	.3	.4	.5	.6	.7	.8
	100						.1	.2	.2	.3	.4	.4	.5	.6	.7
	110						.1	.2	.2	.3	.3	.4	.5	.5	.6
1½" with couplings at Each End	50						.1	.2	.2	.2	.3	.3	.4	.5	.6
	60							.1	.2	.2	.2	.3	.3	.4	.5
	70								.1	.2	.2	.2	.3	.3	.4
	80									.1	.2	.2	.2	.3	.4
	90										.1	.2	.2	.2	.3
	100											.1	.2	.2	.2
	110											.1	.2	.2	.2

From Tests by Ingersoll-Rand Company. For longer or shorter lengths of hose the friction loss is proportional to the length. i.e., for 23 ft.,1/2 of the above; for 150 ft., 3 times the above, etc.

COURTESY OF INGERSOLL-RAND COMPANY

FIGURE 2.1: Pressure Loss in Air Hose Due To Friction. This table may be used to determine the pressure loss in hose connected to rock drills and pneumatic tools. The data applies to hose which has a smooth inner lining. Hose with rough inner lining may have a friction loss as much as 50% greater.

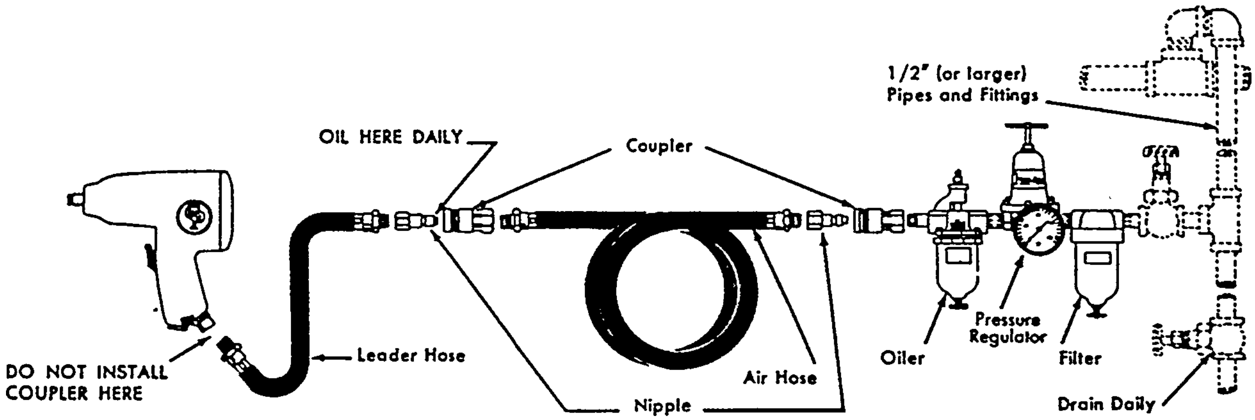


FIGURE 2.2: Typical Air Hose and Coupling Hookup at Tool Station.

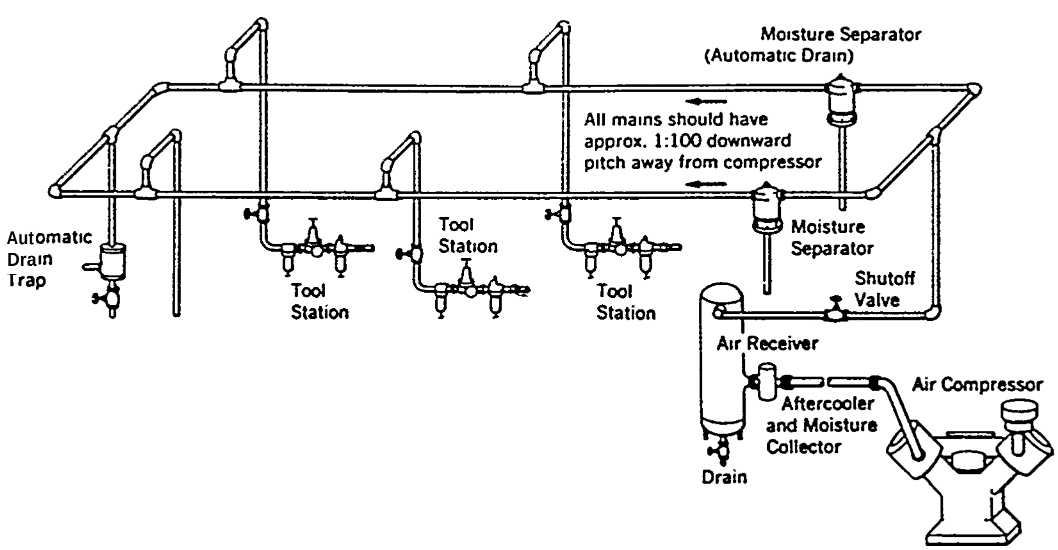


FIGURE 2.3: Recommended Arrangement of Air Piping and Tool Stations.

4. No danger of electrical shock. Operators can work with confidence and safety.

2.3 Selection of TOOLS

When selecting a particular abrasive tool, consider the type of material on which the tool will be employed, noting the amount of available working space and the amount of metal to be removed. These factors, more than any others, should determine the size and type of tool best suited for the job. If the amount of work space is limited, the choice of tool will probably be restricted by the size and type of the grinding wheel or by tool height. When work space is abundant, the amount of metal to be removed is the only restriction.

Tool design is also to be considered when selecting an abrasive tool for a particular job. Horizontal (straight) grinders are ideal for many jobs, but a vertical grinder may be the best choice, especially where tool control and quality finishes are important. Angle grinders and sanders, which feature a construction that reduces overall tool height, are ideal for use in limited access areas where height imposes restrictions.

Light weight and maximum power are also important in the selection of tools.

There are many grinding accessories available for most of the tools used for surface preparation. Abrasive tools have ample power to carry grinding wheels or wire brushes; obtain maximum allowable speeds for each wheel from its particular manufacturer. Safety wheel guards should be used whenever possible.

2.3.1 PROFILES

The many types and sizes of grinders, and of attachments and grit grades, makes the determination of profiles obtained with each particular combination impractical. The profile also depends on the hardness of the material being ground. In general, the profile obtained on most ship grades of steel is slightly less than 0.5 roil, using a grinder equipped with a coarser grade of wheel.

The following typical profiles can be obtained on ship grade steel that has not been abrasive blasted.

1. 0.15 - 0.2 roils with No. 36 grit, Carborundum wheel.
2. 0.25 - 0.3 roils with a depressed center wheel.

2.3.2 REWORK OF MASTER BUTTS AND DAMAGED PAINT

Most shipyard methodology requires surface preparation and coating in the modular stage. The edges of the modules or units to be welded at erection are masked, either by taping or by placing a slit rubber hose over edges. After erection, the welded surfaces and areas affected by heat must be prepared and coated. By keeping the masked edge distances as small as possible, the areas requiring reworking can be minimized.

Most yards prefer to use power tool cleaning to prepare these surfaces because this method eliminates the necessity of grit removal and the possibility of damage to the adjacent coating. Some paint suppliers, however, question whether the quality of cleaning and the profile obtained are adequate for high-build tank coatings and other high-performance coatings. A method that has been used to solve this problem is the preparation of welds by power tool cleaning, with measurement of profiles if necessary. Minimum acceptable criteria should be jointly established by the owner, the paint supplier and the yard, and pictures should be taken and used as standards. This process will eliminate many of the disagreements that normally occur.

2.3.2.1 Power Tool Cleaning Procedure for Erection Joints

The following procedure can be used on vertical, downhand, overhead and structural fillet welds. All welds should first be scaled.

Weld Bead

1. Welds were needle gunned to remove residual slag and deep rust in weld pores. A Cleco-Dresser needle scaler, Model B1 -B, with round-nosed standard needles was used.

2. Welds were then buffed with a cup wire brush. A Cleco-Dresser vertical grinder, Model 15V-45 was used with 3.5" cup wire brush (Osborn knot-type, .020" wire, Model 4220). A Cleco-Dresser horizontal grinder, Model 15 GEL-180, equipped with a Black & Decker 4" radial-type brush (Catalog No. 23201) can be useful in cleaning the edges of welds, comers and other hard-to-reach areas.

   On weld undercuts and restricted areas, a die grinder (Cleco-Dresser, Model 1l-GLF-250,25,000 rpm) equipped with an Osborn

2" ring lock radial wire brush with .014" wire (Model 2080-S-38) proved effective.

Flat Areas and Feather Edging

The removal of rust, burned and smoked paint, and feather edging of paint was accomplished with a vertical grinder (C1eco-Dresser, Model 15-V-45) equipped with a No. 16 grit resin disc pad (Marvel No. C-2 H-D).

Solvent Cleaning

The prepared area was cleaned twice with a solvent recommended by the paint supplier. The solvent was applied and dried with a cloth, and clean solvent and cloth were used for the second application. Any safety-approved solvent can be used.

It should be noted that, using equivalent models available from other equipment manufacturers, equivalent results can be obtained.

2.3.2.2 Profile

To determine the profile obtained by power tool cleaning of butt welds, a similar butt-welded panel was prepared and was closed-cycle abrasive blasted. The profile was measured with a Bendix Profilometer Amplimeter, Model 18. A 4-4.5 roils profiIe was obtained. This profile is approximately 1 mil deeper than that normally obtained in production, as a result of the addition of new grit.

The panel was allowed to rust and the weld was prepared as previously described. The remaining profile of the areas prepared by cup and radial wire brush was 3.75 -4.0 roils, as compared to 2.0 roils in the areas prepared by disc sanding.

While the profile obtained was reduced, sufficient profile remained to meet the requirements of tank coating applications.

2.3.2.3 Weld Preparation Standard

Figure 2.4 depicts in reduced scale (0.67:1) a typical master butt weld prior to repair. The width to be prepared, including feathering of paint film, is approximately 2 inches.

Figure 2.5 depicts in reduced scale (0.75:1) a typical master butt weld that has been power tool cleaned as specified in section 2.3.2.1. Figure 2.6 depicts the same power-cleaned weld at a magnification of 1.31:1. This weld is vertical, but it is typical of the standard that can be obtained on the overhead, deck and structural fillet welds.

Figure 2.7 depicts a standard of cleanliness, at 3X magnification, that was accepted for the application of a high-build, ketamine-cured epoxy tank coating by the paint supplier and the owner.

2.4 Vertical Grinders

The vertical grinder seems to be the portable tool most frequently used in preparing surfaces for painting in shipyards. With a speed range of 3,000- 18,000 rpm, the vertical grinder can be used for sanding and wire brush work. Attachments, such as cup grinding wheels, disc wheels, sanding pads, cup wire brushes and coated abrasive flap wheels, make it a very versatile and effective tool. Light-to-heavy sanding and general finishing can be accomplished very effectively.

2.4.1 APPLICATIONS

Vertical grinders are most effective in the following operations.

1. Depressed center wheel and cut wheel grinding.
2. Finishing work on painted or smooth surfaces.
3. Jobs where horizontal tools cannot be used.
4. Light-to-heavyduty sanding, where rapid removal of material is required, and wire brushing.
5. Operations where high quality blending and feathering are needed.
6. Sanding operations where coated abrasive discs are recommended.
7. Finishing and snagging.

2.4.2 DESCRIPTION AND MODELS

Figures 2.8, 2.9, 2.10 and 2.11 present commonly encountered grinding tools and manufacturers' data.

2.4.2.1 Accessory Description

Figures 2.12, 2.13, 2.14, 2.15, 2.16 and 2.17 present commonly encountered grinder accessories and manufacturers' data.

2.5 Horizontal Grinders

Horizontal (straight) grinders are ideal for many jobs. They have a fairly wide range of speeds and can accomplish medium-to-heavy grinding. Horizontal grinders have numerous attachments, including radial wheels, wire brush wheels, cone wheels, buffing wheels and belts. They can often be used in limited or difficult-to-reach areas.

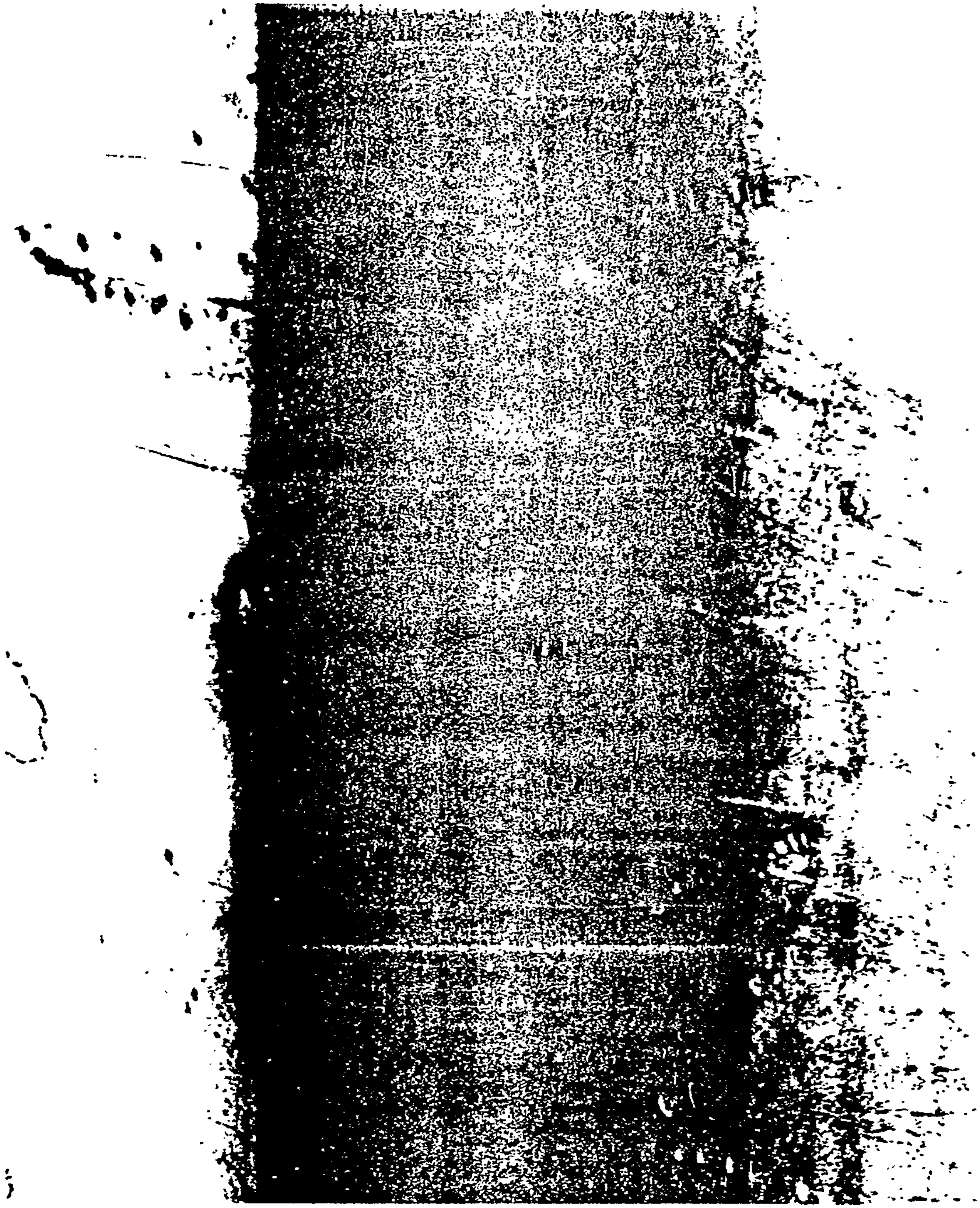


FIGURE 2.4: Typical Master Butt Weld Prior to Repair. (0.67:1 Magnification)

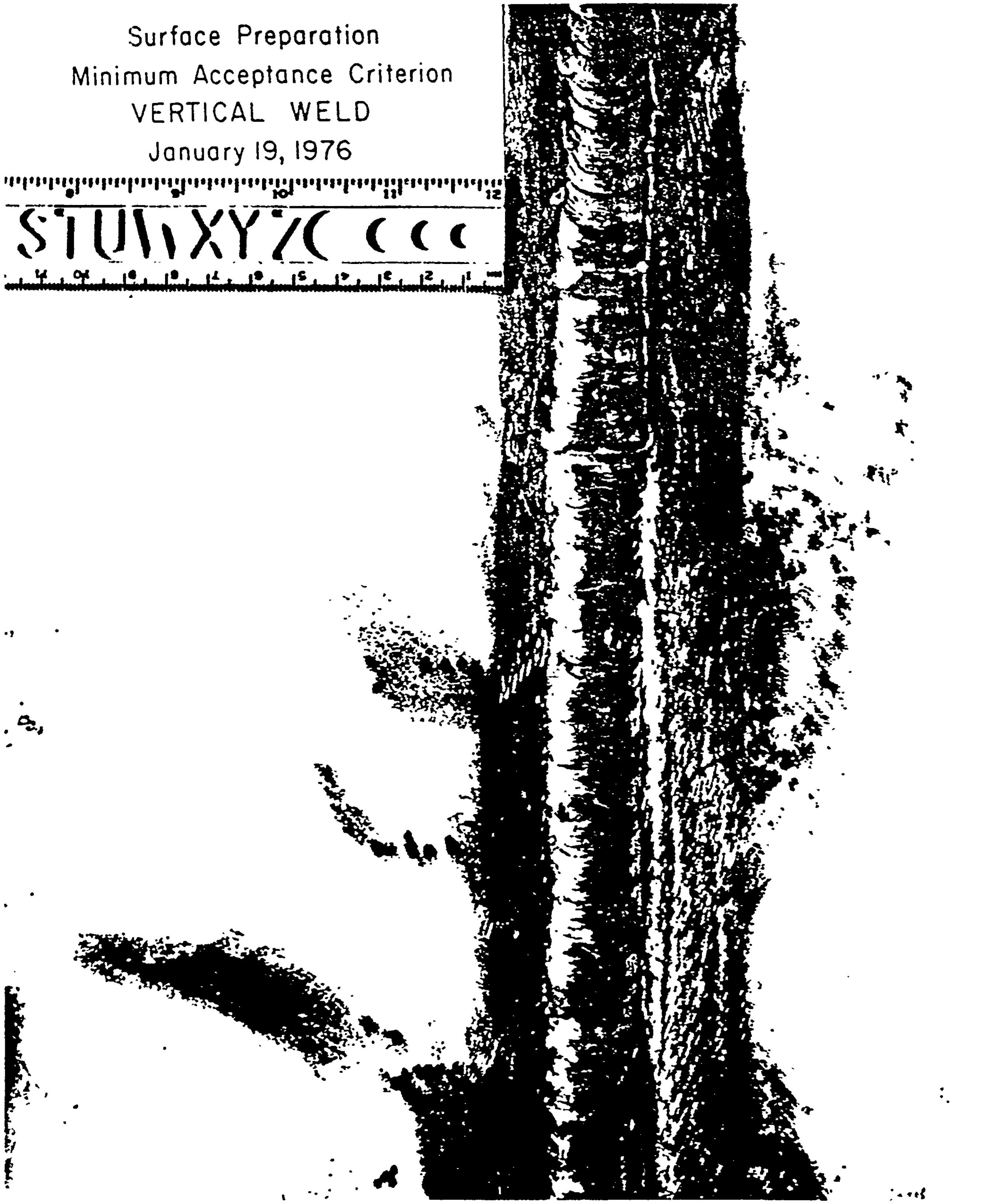


FIGURE 2.5: Typical Master Butt Weld, Cleaned by Power Tool. (.075:1 Magnification)

FIGURE 2.6: **Power-Cleaned Master Butt Weld. (1:1.31 Magnification)**

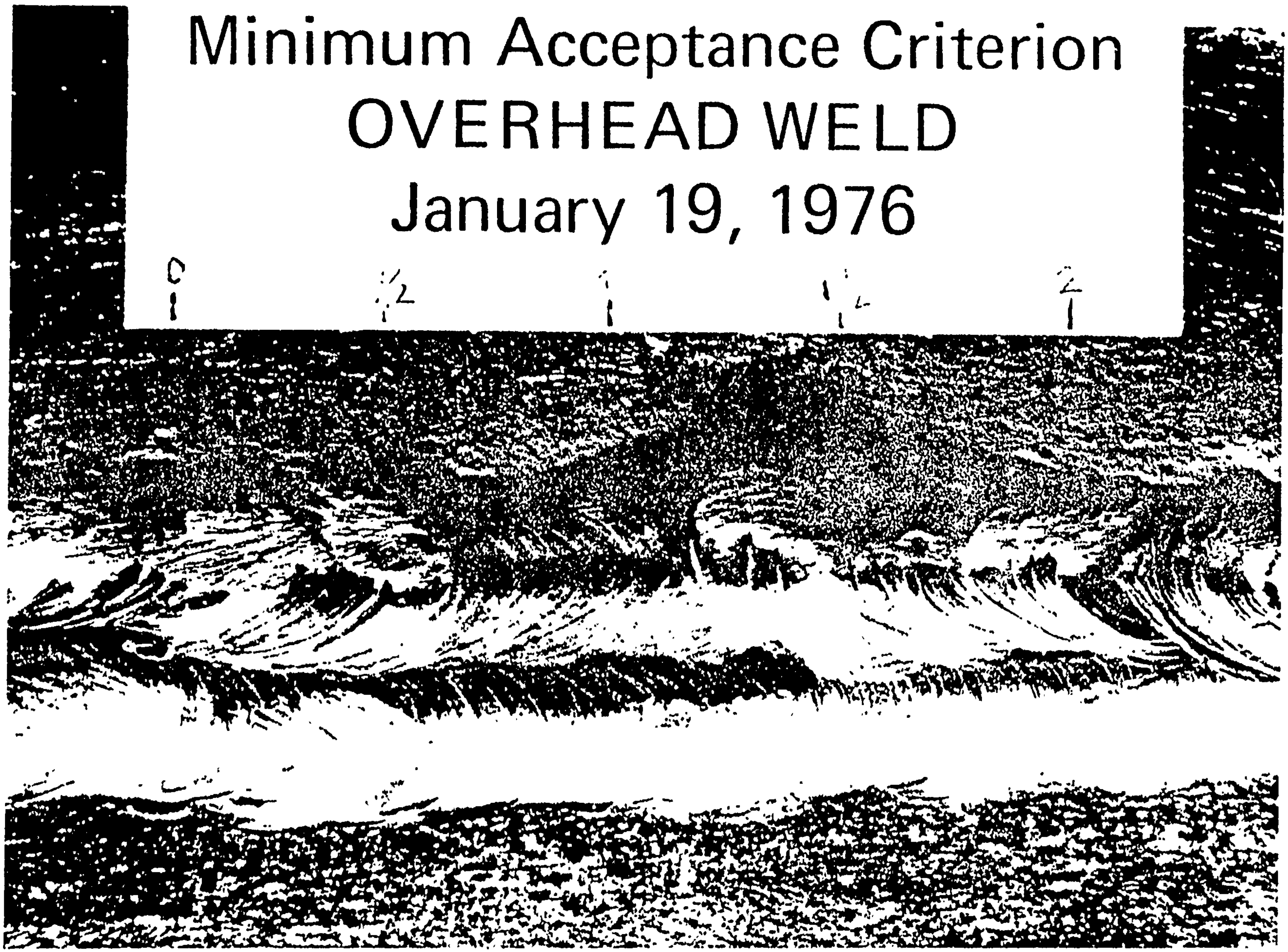
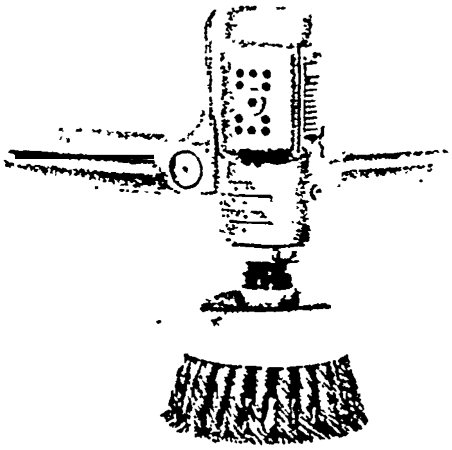


FIGURE 2.7: Acceptable Standard of Cleanliness. (3:1 Magnification)



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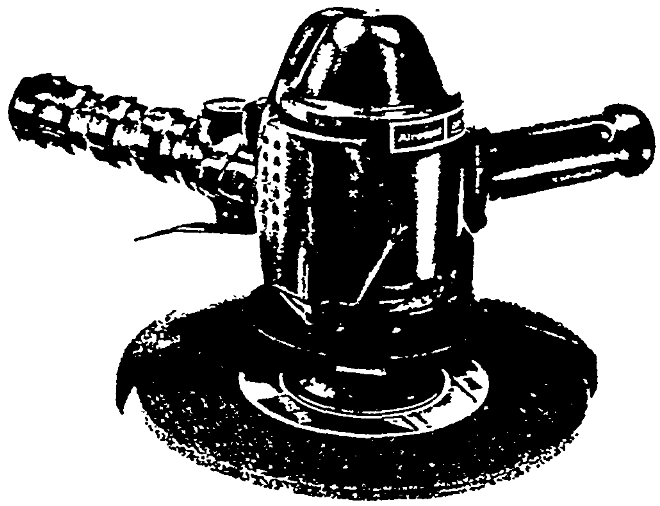
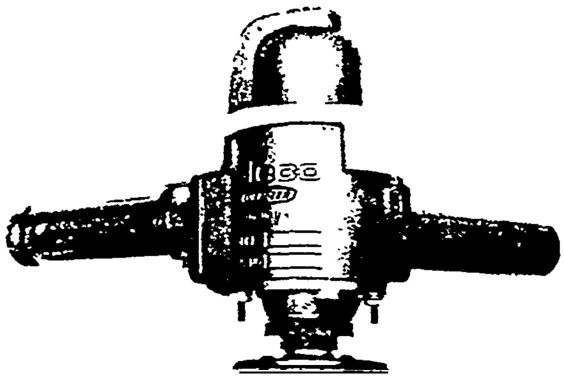


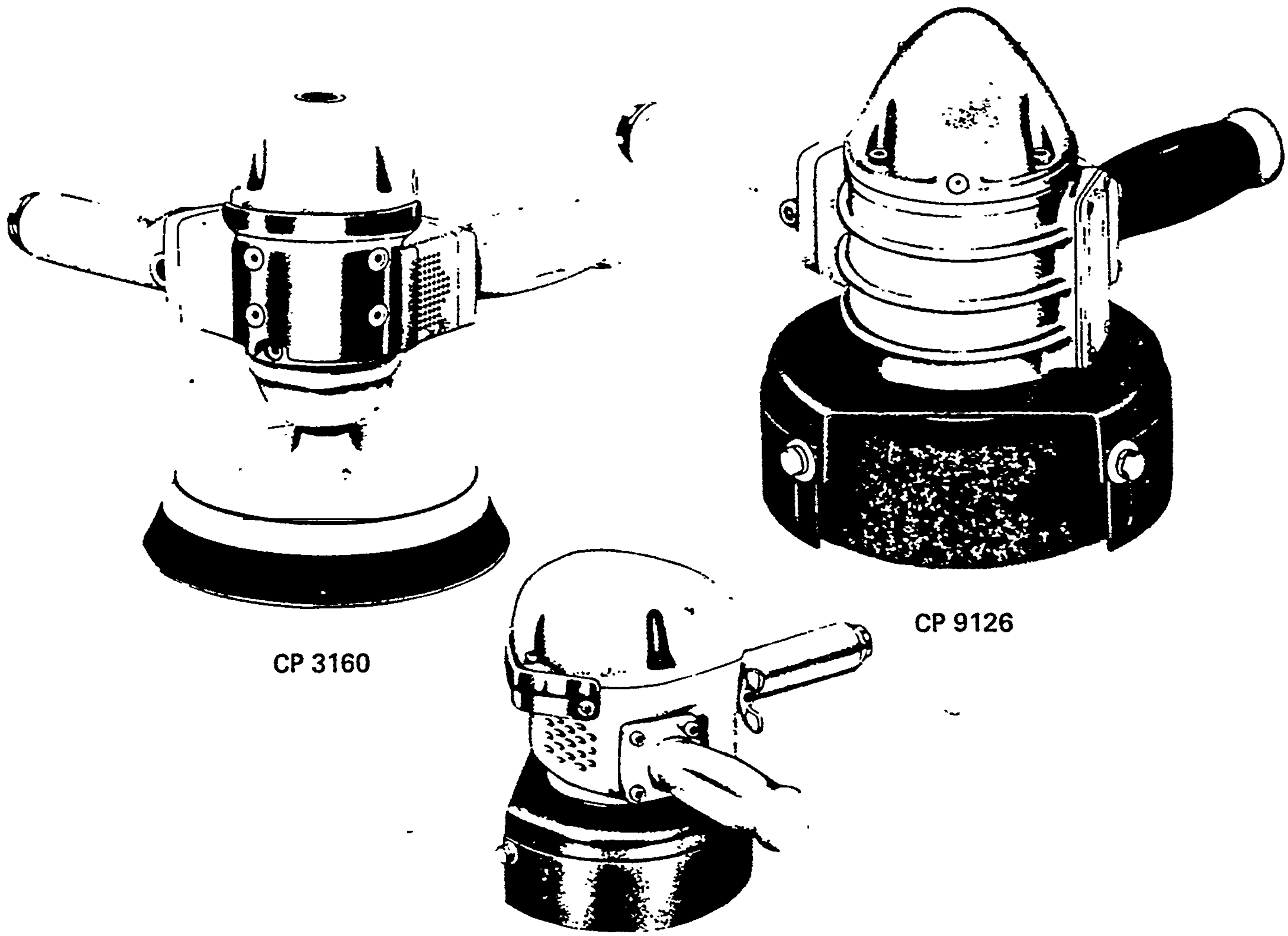
5201



5560-L

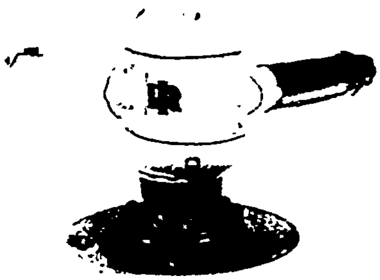
Tool: **VERTICAL GRINDER**			
Manufacturer: CLECO			
Model:	**15-V-30**	**5560-L**	**5201**
Speed:	**3000**	**6000**	**4500**
Weight:	**4 lb.**	**5 lb. 11 oz.**	**9½ lb.**
Height:	**5-5/8"**	**6-3/8"**	**7½"**
Arbor Size:	**5/8"-11**	**5/8"-11**	**5/8"-11**
Power:	**Air**	**Air**	**Air**
Inlet Size:	**3/8"**	**½"**	**½"**
Outlet Size:	**3/8"**	**½"**	**¾"**
Cup Wheel Capacity:		**6"**	**6"**

FIGURE 2.8: Vertical Grinders.



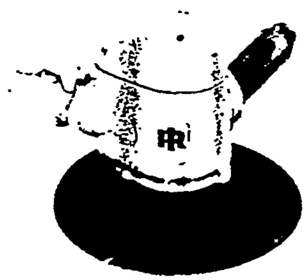
Tool: VERTICAL GRINDER			
Manufacturer: CH I PNEU			
Model:	CP-3160 SAMBARI	CP-3321 HAMAVET	CP-9126 45
Speed:	3000	6000	4500
Weight:	5½ lb.	9-5/8 lb.	10½ lb.
Height:	6-1/16"	6-5/8"	6-5/8"
Arbor Size:	5/8"-11	5/8"-11	5/8"-11
Power:	Air	Air	Air
Inlet Size:	½"	½"	½"
Outlet Size:	½"	¾"	¾"
Cup Wheel Capacity:	4" cup wire brush	6"	6"

FIGURE 2.9: Vertical Grinders.



11F77LD2

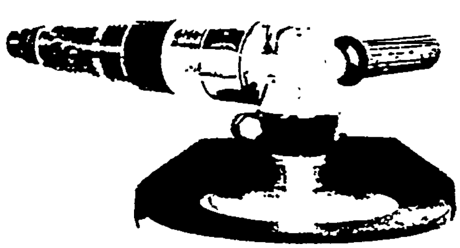
43F40LD1



22F45LA1

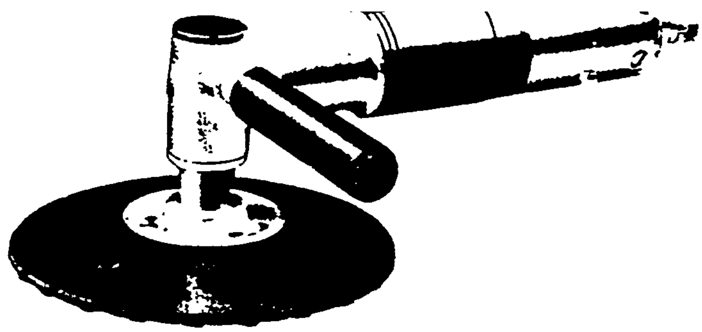
Tool: VERTICALGRINDER			
Manufacturer: INGERSOLL-RAND			
Model:	**11 F77LD2**	**22 F45LA1**	**43 F60LD1**
Speed:	**7700**	**4500**	**6000**
Weight:	**5 lb.**	**7-7/8 lb.**	**11½ lb.**
Height:	**6-7/8”**	**7¼”**	**8“**
Arbor Size:	**5/8”-11**	**5/8”-11**	**5/8”-11**
Power:	**Air**	**Air**	**Air**
Inlet Size:	**3/8”**	**½”**	**½“**
Outlet Size:	**3/8”**	**3/4”**	**3/4”**
CupWheel Capacity:	**4“**	**6"**	**6″**

FIGURE 2.10: Vertical Grinders.



15 G-80RA

CP-3417



GAIL60DI

Tool: ANGLE GRINDER			
Manufacturer:	CLECO	ING-RAND	CHI PNEU
Model:	15 G-80RA	GAIL60DI	CP-34I7-SALABUN
Speed:	8000	6000	4500
Weight:	5 lb.	8-3/4 lb.	4-7/16 lb.
Length:	9-1/16"	14¼"	10-3/4"
Height:	—	4-7/16"	4"
Arbor Size:	5/8"-11	5/8"-11	5/8"-11
Power:	Air	Air	Air
Inlet Size:	3/8"	1/4"	1/4"
Outlet Size:	3/8"	1/2"	3/8"
Wheel Capacity:	—	6"	–

FIGURE 2..11: Angle Grinders.

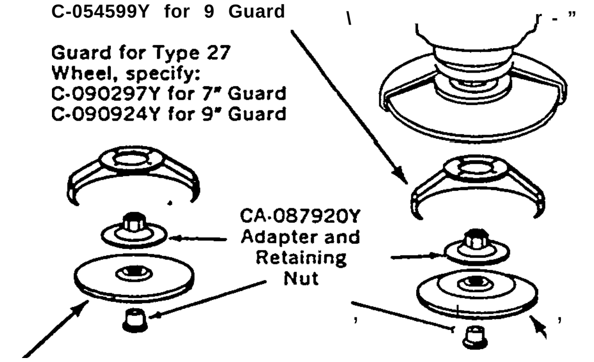
GRINDER/SANDER ACCESSORIES

FOR DEPRESSED CENTER REINFORCED WHEELS

Guard for Type 28 Wheel, specify:
C-054600Y for 7 Guard
C-054599Y for 9 Guard

Type 27 and Type 28 Guard

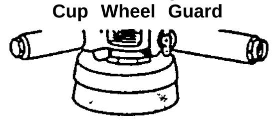
Guard for Type 27 Wheel, specify:
C-090297Y for 7" Guard
C-090924Y for 9" Guard



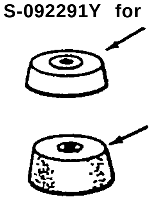
Type 27-Depressed Center Wheel Type 28–Dished Wheel

FOR FLARED CUP WHEELS

Rotating Cup Wheel Guard

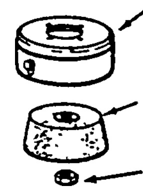


Rotating guard for cup wheels:
S-097439Y for 4 Guard
S-092291Y for 6 Guard

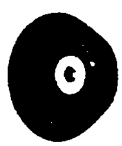


Skirt-type Cup Wheel Guard

Stationary guard for cup wheels, specify:
C-089774Y for 4 Guard
C-090296Y for 6 Guard



FLARED CUP WHEELS* (ORGANIC BONDED) Type #11 Shape; ⅝"—11 Threaded Insert

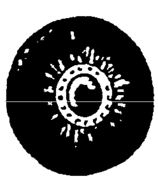


Flared Cup Wheel

Wheel Size (inches)			Max. RPM	General Purpose, Low Carbon Steel, Manganese Steel, Annealed Malleable	Stainless and High Carbon Steel	Gray Iron and Malleable Unannealed	Steel Plate and Welds
Dia.	Thick-ness	Face					
4	2	¾	9000	C-084958Y	—	—	C-084961Y
6	2	1¼	6000	C-084970Y	C-084971Y	C-084972Y	C-084973Y

*All wheels are coarse (24-36) grade.

RADIAL WIRE BRUSHES—KNOT TYPE CONSTRUCTION



Part No.	Recommended Tool and Speed	Dia. (inches)	Arbor Hole (inches)	Width (inches)		Wire Size Diameter (inches)	Texture
				Face	Hub		
C-047524Y	CP-9114 (18,000 RPM)	3⅛	⅜	⅜	½	.0118	Fine
C-047523Y	CP-9114 (18,000 RPM)	3⅛	⅜	⅜	½	.014	Medium
C-047522Y	CP-9114 (18,000 RPM)	3⅛	⅜	⅜	½	.020	Coarse

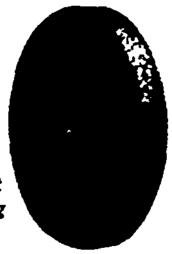
CUP BRUSHES—KNOT TYPE, MUSIC WIRE CONSTRUCTION

Type	Part No.	Recommended Tool and Speed	Diameter (inches)	Threaded Arbor Hole	Wire Size Diameter (inches)	Texture
Single Row Type (For General Use)	C-039446Y	CP-9123 (4,500 and 6,000 RPM)	4	⅝"—11	.035	Coarse
	C-038119Y	CP-9123 (4,500 RPM) CP-9126 (4,500 RPM) (6,000 RPM)	6	⅝"—11	.023	Medium
Double Row (For Heavy-Duty Use)	C-085096Y	CP-9126 (4,500 and 6,000 RPM)	6	⅝"—11	.023	Medium

FIGURE 2.12: Grinder/Sander Accessories by Chicago Pneumatic Tool.

GRINDER/SANDER ACCESSORIES 1

STRAIGHT GRINDING WHEELS*

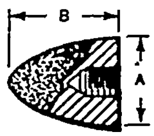


Straight Grinding Wheel

Wheel Size (inches) Dia.	Width	Arbor Hole	Bond	Max. RPM	Recommended Tool and Speed	General Purpose, Low Carbon Steel, Manganese Steel, Annealed Malleable	Stainless Steel, High Carbon Steel
2	½	⅜	Organic	18,000	CP-9114 (18,000 r.p.m.)	C-084986Y	C-084987Y
3	½	⅜	Organic	12,000	CP-9114 (12,000 r.p.m.)	C-047540Y	C-047541Y

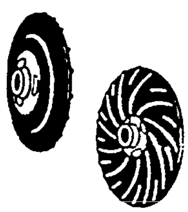
*All wheels are coarse (24-36) grade.

CONE WHEELS—COARSE (24-36) GRADE



Diameter (A) (Inches)	Length (B) (Inches)	Max. Safe RPM	Recommended Tool and Speed	Arbor	Use: General Purpose Steel and Annealed Malleable
1½	2½	24,000	CP-9114 (18,000 r.p.m.)	⅜"—24	C-052103Y
1½	3	24,000		⅜"—24	C-052104Y

DISC SANDING PADS (threaded ⅝"—11; used with C-089784Y spacer)



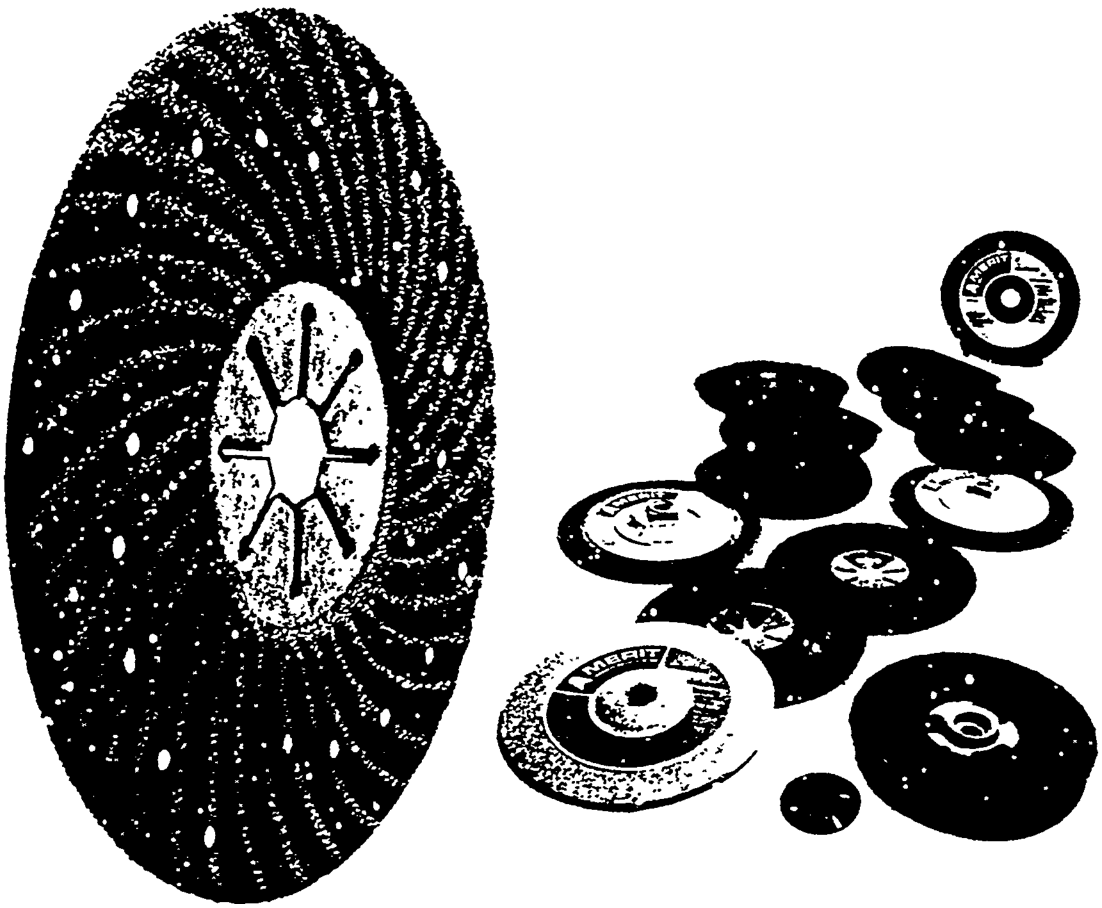
The Spiralcool pads listed below are strong. light in weight and perfectly balanced. The unique design creates air flow behind the abrasive disc, cooling the disc and reducing load-up and glazing.

Texture	Dia. (inches)	Type	Material	Part Nos. Pad and Nut	Nut Only	Spanner
Medium	5	Spiralcool	Rubber Reinforced	S-091833Y	US-068790Y	S-067920Y
Medium	7	Spiralcool	Rubber Reinforced	S-091836Y	US-068790Y	S-067920Y
Medium	9	Spiralcool	Rubber Reinforced	S-091839Y	US-068790Y	S-067920Y

DEPRESSED CENTER REINFORCED WHEELS All wheels are coarse (24-36) grade.

Dia. (Inches)	Thick-ness (inches)	Arbor Hole (inches)	Max. RPM	Recommended Tool and Speed	Part No.	Use	Guard Required	Adapter Required
TYPE 27								
9	¼	⅝	6000	CP-9123 CP-9126 (6000 r.p.m.)	C-047514Y	Stainless and structural steel, bronze and cast iron.	C-090924Y	C-087920Y
9	⅛	⅝	6000	CP.9123 CP-9126 (6000 r.p.m.)	C-047516Y	Free cutting sides for notching and clean up on castings, steel, aluminum, cast iron and pipe.	C-090924Y	C-087920Y
7	¼	⅝	7750	CP-9123 (7700 r.p.m.)	C-047517Y	Light weld removal, smoothing and finishing steel.	C-090297Y	C-087920Y
7	¼	⅝	7750	CP-9123 (7700 r.p.m.)	C-047513Y	Weld grinding and snagging.	C-090297Y	C-087920Y
7	⅛	⅝	7750	CP-9123 (7700 r.p.m.)	C-.047515Y	Free cutting sides for notching and clean upon castings, steel. aluminum, cast iron and pipe.	C-090297Y	C-087920Y
HEAVY-DUTY TYPE 28								
9	¼	⅝	6000	CP-9123 CP-9126 (6000 r.p.m.)	C-047519Y	Weld grinding; cleaning castings, steel, stainless, bronze and aluminum alloys.	C-054599Y Optional equip. on recoin. tool.	C-087920Y
7	¼	⅝	7750	CP-9123 (7700 r.p.m.)	C-047518Y	Weld grinding; cleaning castings, steel, stainless, bronze and aluminum alloys.	C-054600Y Optional equip. on recoin. tool.	C-087920y'

FIGURE 2.13: Grinder/Sander Accessories by Chicago Pneumatic TooL



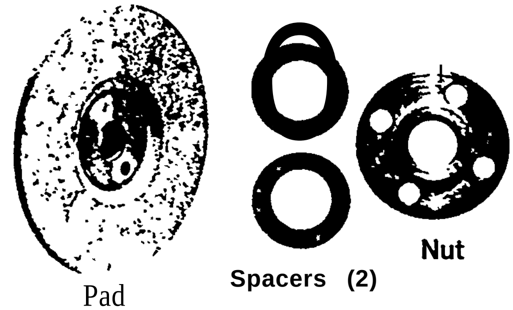
GRIT SIZES								
DIA.	16	24	36	50	60	80	100	120
5″		x	x	x	x	x	x	
7″	x	x	x	x	x	x	X	x
′ silicon carbide		x	x					

FfGURE 2.14: Depressed Center, Resin Fibre, Semi-Flex Discs by Merit.

FLEXIBLE PAD, NUT, *AND* SPACERS

Model	Pad Size		Nut	Spacers (2)
	7 In.	9 in.		
2600,5100,5200, and 2100 Series	849261	849260	849259	843851
15-RA, 15-V, 5500	849261	......	849259	843851

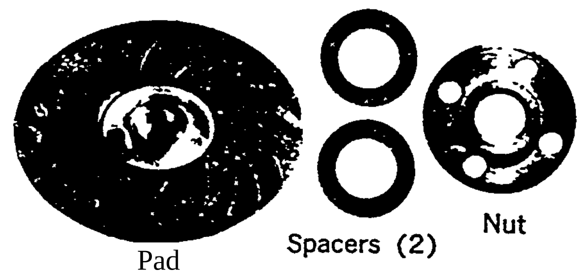
NOTE: When used, also order 2 spacers (843851) and one nut (849259).



SPIRAL COOL RUBBER PAD, NUT AND SPACERS

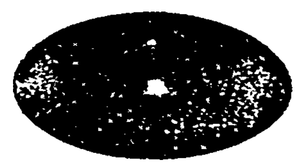
Model	Pad Size*				Nut	Spacers (2)
	4 in.	5 in.	7 in.	9 in.		
2600, 5100., 5200,2100	......	......	849913	849914	849259	843851
15.RA, 15-V, 5500	......	......	849913	......	849259	843851
11-G-110RA	889271	849848	....	.	849259	843851

*NOTE: When used, also order 2 spacers (843851) and one nut (849259).



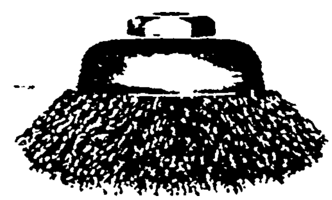
7 1n. SPONGE RUBBER POLISHING PAD

Model	Cleco Code No.
15V30 and 15 RA	849729



WIRE BRUSHES 5/8 IN. ARBOR

Type	Size	Cleco Code No.
cup	4 in.	849226
cup	6 in	849227
Radial	6 in.	849228
Radial	8 in.	849229

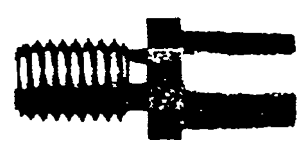


ROUTER ATTACHMENT

Model	Cleco Code No.
No. 11 Series	881390

SPINHOLE ADAPTORS

Thread	Cleco Code No.
5/8 in. x 11 External 3/8 in. x 24 Internal	849167
5/8 in. x 11 External 1/2 in. x 20 Internal	843464



ARBOR EXTENSION
(For Radial and Cone Wheels)

Cleco Part Name	Cieco Code No.
1/4 in.	881252
3/8 in.	881253

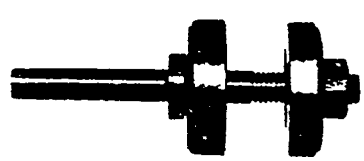


FIGURE 2.15: Grinder Accessories by Cleco.

ADAPTOR KIT FOR EDGE GRINDERS

Cleco Code No.	849269

EDGE GRINDER WHEEL GUARDS

Model	3 in.	4 in.	6 in.	7 in.	9 in.
11-G-110RA		889202			
12V-180	*849905*				
15.RA				865986	
15V				849760	
5500				*867173*	
55120			886177		
2600				*847698*	*847776*
550-V				412990	412993
650-V				412990	412993
550-V Koolle				414136	414137
650-V Koolle				414136	414137
2100				889321	889322

REVOLVING WHEEL GUARD (FLARED)

Models	4 in.	5 in.	6 in.
5500,2600, 550-V, 650-V, and 2100 Series	849842	849841	849840

WHEEL GUARDS FOR HORIZONTAL GRINDERS

Model	2 In.	21/2 in.	3 in.	4 in.	6 in.	8 in.
400	412884					
407			412888			
214 JA, JHA		849094				
214 A, FA, FHA,		849093				
15G-120			865786			
15G-140-180		865787				
15GE-90-120			885689			
15GE-140-180		865780				
15GE.90				865987		
560					881607	
590,5120				881608		
550-H-45						413782
550-H-60					413781	
650-H-45						413782
650-H-60					413781	
845						849235
860					849234	849235

STATIONARY WHEEL GUARDS

M0del	4 in.	5 in.	6 in.
2600			341504
550-V		412996	412988
650-V		412996	412988
2100			881841

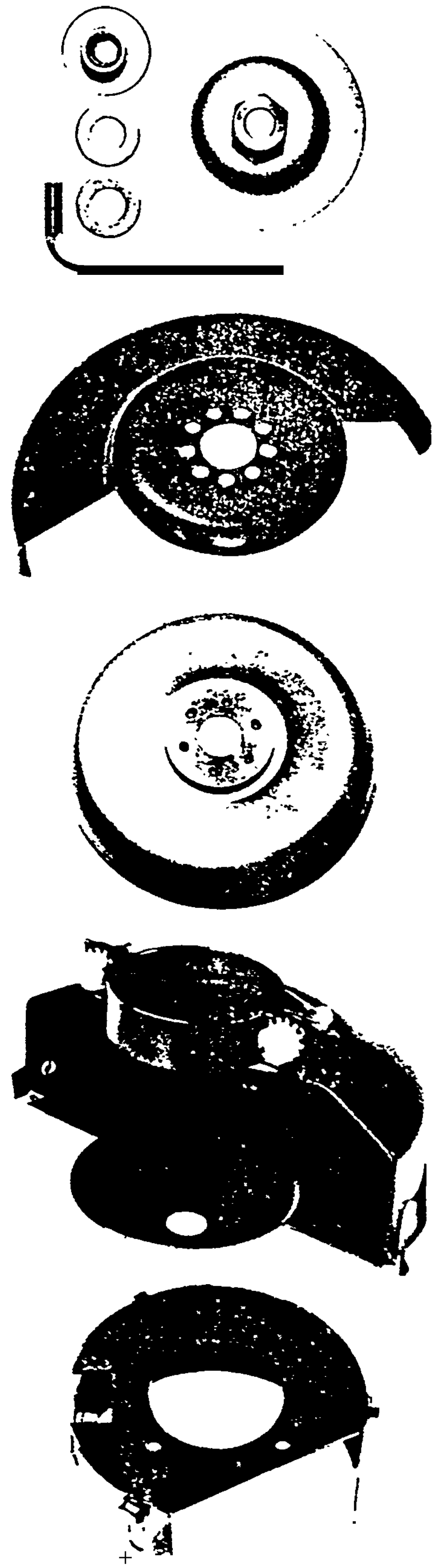
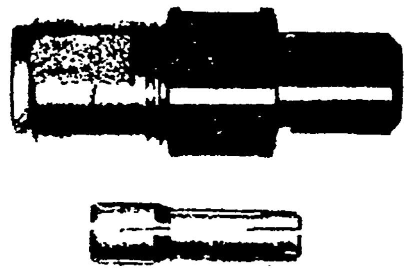


FIGURE 2.16: Grinder Accessories by Cleco.

ERICKSON COLLETS AND CHUCKS

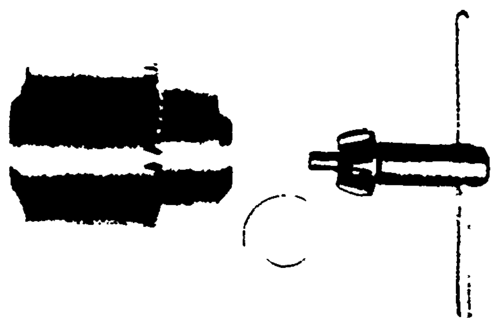
Model	Cleco Part Name	Cleco Code No.
No. 6 Series	Chuck Assy. Less Collet (5/16 in.—24 Thread)	841937
No. 11 Series	Chuck Assy. less Collet (3/8 in.—24 Thread)	841939
*No. 125 Series	Collet Chuck	881715
No. 6 & No. 11 Series	1/8 in. Collet	847534
No. 6 & No. 11 Series	3/16 in. Collet	847535
No. 6 & No. 11 Series	1/4 in. Collet	847523
No. 125 Series	1/4 in. Collet	847811
No. 125 Series	3/8 in. Collet	847805

*Except Extended Models Which Have An Integral Chuck.



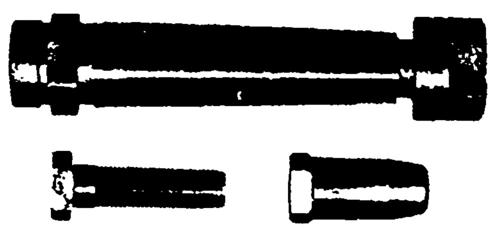
THREE JAW CHUCK. KEY AND SPACER

Cleco Part Name	Cleco Code No.
1/4 in. Chuck	849102
Key #1	849116
Spacer	847529



COLLET CHUCKS

Model	Cleco Part Name	Cleco Code No.
125-G	1/4 In. Collet	847811
125-G	3/8 In. Collet	847805
125-G	1/4 In.-3 in. Extended Collet	849997
214	1/8 In. Collet	849140
214	3/16 In. Collet	849141
214	1/4 In. Collet	849142
214	3/8 In. Collet	849416



RUBBER FLEX COLLETS AND CHUCKS

Model	Cleco Part Name	Cleco Code No.
No. 11 & 214 Series	Chuck Assembly Less Collet (3/8 in.—24 Thread)	881714
	1/8 in. Collet	847532
	1/4 in. Collet	847533

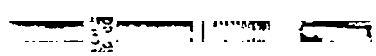


FIGURE 2. 17: Grinder Accessories by Cleco.

2.5.1 APPLICATIONS

Horizontal grinders are most effective in the following operations.

1. Medium-to-heavy duty maintenance work involving grinding, sanding or wire brushing.
2. Cleaning tanks and vessels of all types, the insides of large pipe fittings and casting interiors.
3. Removal of weld flux and weld splatter with a wire brush.
4. The use of heavy-duty grinders, when metal removal is of primary concern, and in foundries, for snagging castings and removing fins.
5. Many operations in which, due to its shape, a vertical grinder cannot be used.

2.5.2 DESCRIPTION AND MODELS

Figures 2.18, 2.19 and 2.20 present commonly encountered horizontal grinders and manufacturers' data.

2.5.2.1 Accessory Description

Figures 2.21, 2.22 and 2.23 present commonly encountered grinding accessories and some accompanying data.

2.6 Die Grinders

Die Grinders are frequently used. Because they are not rugged tools, however, they are not used for heavy grinding. With speeds of up to 60,000 rpm, they are employed for a variety of touch-up, spotting and finishing jobs. The die grinder affords excellent portability and access to confined areas. The project found that some yards are getting a great deal of work out of the tool, perhaps more than its designers originally anticipated. In fact, one yard has said that the die grinder is "probably the single most useful air tool for shipbuilding." Thus, it may be the most versatile of all the small grinders.

2.6.1 APPLICATIONS

Die grinders are most effective in the following operations.

1. The use of a cone wheel for work in comers.
2. Metal shaving or removal and grinding.
3. Deburring and weld cleanup.
4. Polishing and light finishing.
5. Internal pipe finishing.
6. Sheetmetal work.

2.6.2 DESCRIPTION AND MODELS

Figures 2.24 and 2.25 present some available die grinders and manufacturers' data.

2.6,2.1 Accessory Description

Figures 2.26 and 2.27 present some commonly encountered die grinder tools and accessories with accompanying data.

2.7 Scalers (Piston Scalers and Needle Guns)

Scalers are primarily of two types: the piston variety and the type which accommodates needles and chisels. The latter type has a quick-change positive lock retainer which enables it to be converted to either a needle gun or a scaling gun with a chisel. These needles and chisels can strike hundreds of times per minute, performing many applications which previously required wire brushing or blasting. The aggregate of needles varies from 12 to 111; the needles conform to irregular surfaces, rivets, screw heads, channels, crevices, grooves, joints and flat surfaces. The needle gun is a valuable tool for cleaning weld joints, resulting in substantial production savings over other time-consuming and costly weld cleaning methods.

The piston type of scaler uses no chisel; instead, the hammer piston itself acts as a chisel. It delivers a very rapid vibratory action which effectively removes old paint, rust and scale without damaging the metal surface.

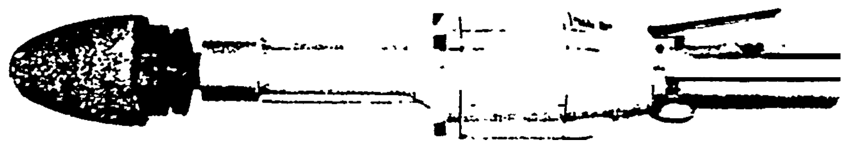
The use of scalers by shipyards is common. While their production rates are not fast, these tools, when used correctly, are the best available for some applications.

Periodic inspection and maintenance are required to insure efficiency of operation. Needle sharpness and straightness must be maintained.

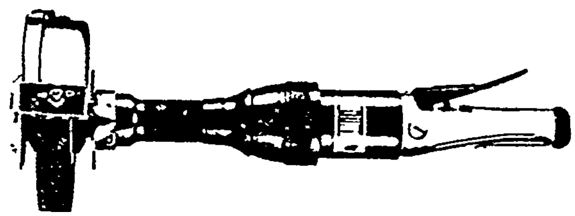
2.7.1 APPLICATIONS

Scalers are most effective in the following operations.

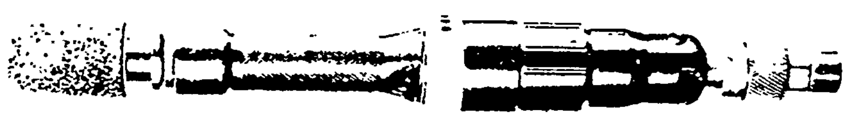
1. General scaling, beading and weld-splash removal.
2. Paint and rust removal.
3. Removal of scale in holes and grooves.
4. Use on decks, tanks, bulkheads or other large surfaces, either singly or mounted in groups.



550-HL-45



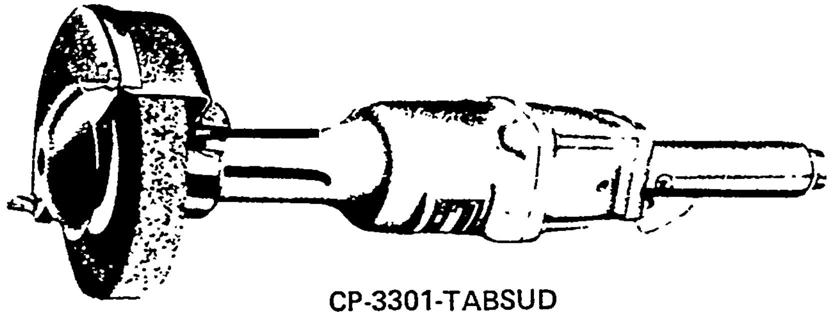
590-BTB



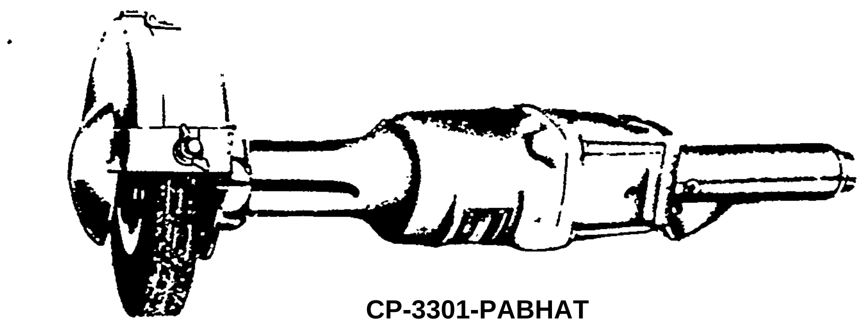
15GE-180

Tool: HORIZONTAL GRINDER			
Manufacturer: CLECO			
Model:	550-HL-45	590-BTB	15GE-180
Speed:	4500	9000	18,000
Weight:	10 lb. 8 oz..	6 lb. 10 oz..	4 lb. 2 oz..
Length:	20-1/8"	16-3/8"	12-1/16"
Arbor Size:	5/8"-11	5/8"-11	3/8"-24
Power:	Air	Air	Air
Inlet Size:	½"	½"	3/8"
Outlet Size:	½"	½"	3/8"
Wheel Capacity:	6"	Cone 3"	1-3"

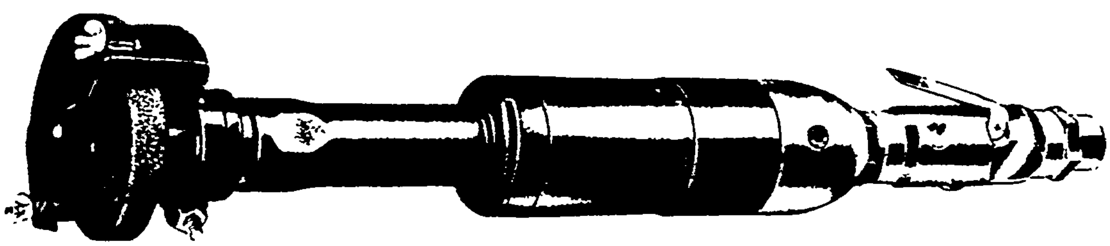
FIGURE 2.18: Horizontal Grinders.



CP-3301-TABSUD



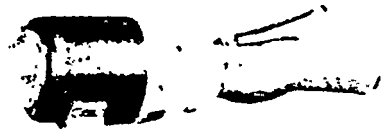
CP-3301-PABHAT



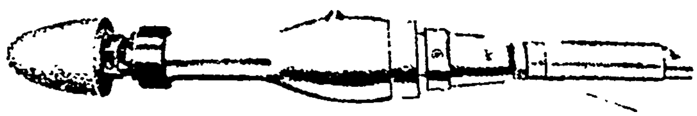
CP-3070-LELPUG

Tool: HORIZONTAL GRINDER			
Manufacturer: CHI PNEU			
Model:	CP-3301-TABSUD	CP-3301-PABHAT	CP-3070-LELPUG
Speed:	4500	8000	18,000
Weight:	11-5/8 lb.	11-3/41b.	4-3/4 lb.
Length:	23"	21½"	17¼"
Arbor Size:	5/8"-11	1"	3/8"-24
Power:	Air	Air	Air
!nlet Size:	½"	½"	3/8"
Outlet Size:	3/4"	3/4"	½"
Wheel Capacity:	8"	8"	2"

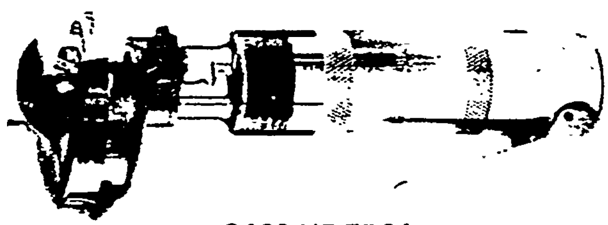
FIGURE 2.19: Horizontal Grinders.



31L45B1



2C1L90C1



G160-HDEB21

Tool: HORIZONTAL GRINDER			
Manufacturer: INGERSOLL-RAND			
Model:	31L45B1	2C1L90CI	G 160-HDEB21
Speed:	*4500*	*9000*	*18,000*
Weight:	14-3/4 lb.	8-1/8 lb.	2-3/4 lb.
Height:	23-7/8"	21¼"	8-9/16"
Arbor Size:	5/8"-11	5/8"-11	3/8"-24
Power:	Air	Air	Air
Inlet Size:	½"	½"	¼"
Outlet Size:	¾"	½"	3/8"
Cup Wheel Capacity:	8"	—	3"

FIGURE 2.20: Horizontal Grinders.

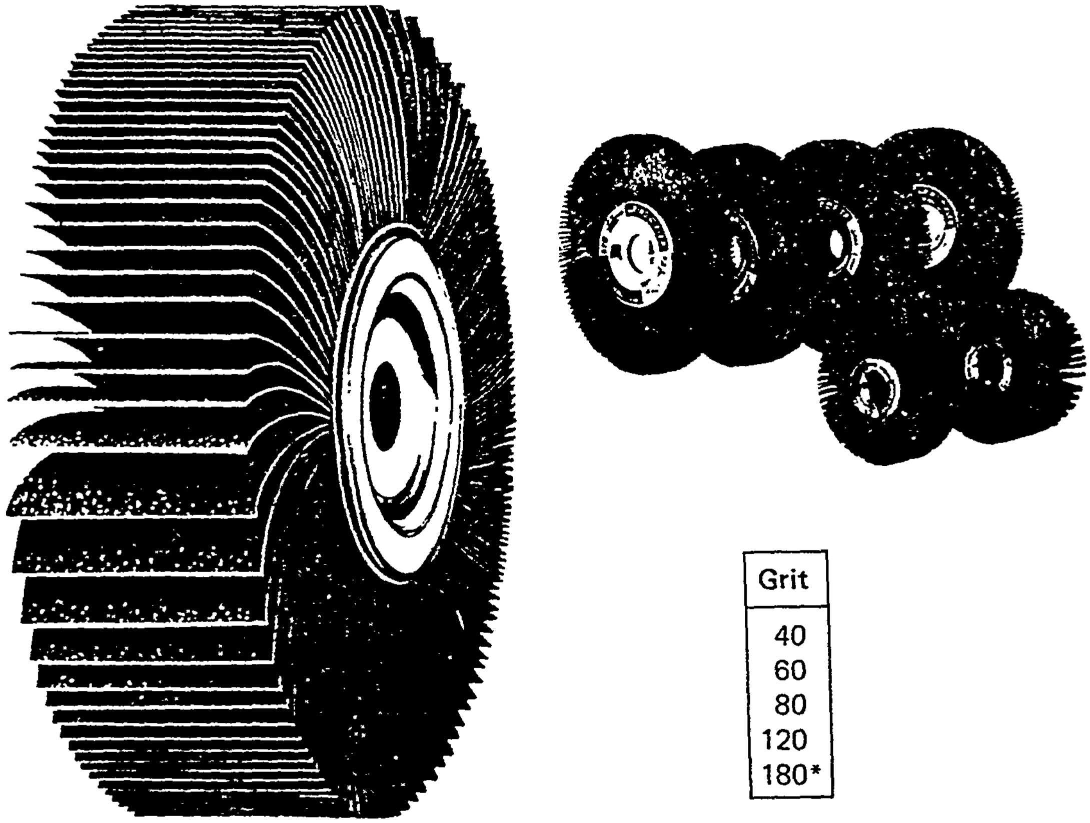


FIGURE 2.21: Grind-O-Flex Wheels by Merit.

NU-MATIC® air inflated wheels

ORDER NO.	WHEEL SIZES AND SPECIFICATIONS	NET PRICE EACH	ABRASIVE BANDS SIZE	[illegible]	200 [illegible] (1-4 UNITS) NET PER C
M223	2-1/4 dia. x 2-3/4 wide Std. holes 5/8-11. 1/2-13 Max. safe rpm. 9000	$34.50	3 x 7-1/4 200/unit 10 bands $3.80 net	100F 80 60 50 40	$26.20 26.65 27.55 28.30 29.20
M320 "c"	3 dia. x 2 wide Std. holes 5/8, 1/2, 3/8 Plain or threaded" Max. hole 7/8 Max. safe rpm. 8000	34.50	2-1/4 x 9-5/8 200/unit 10 bands $3.30 net	100F 80 60 50 40	22.95 23.45 24.20 25.00 25.70
M331	3-1/4 dia. x 3 wide Std. holes 5/8, 1/2, 3/8 Plain or threaded" Max. hole 314 Max. safe rpm. 8000	37.50	3x10-11/16 50/unit 10 bands $4.40 net	100F 80 60 50 40	29.85 30.60 31.80 32.70 33.95
M525 "c"	5 dia. x 2-1/2 wide. Std. holes 518, 1/2 Plain or threaded" Max. safe rpm. 6000	35.70	2-3/4 x 15-1/2 50/unit 10 bands $6.80 net	100F 80 60 50 40	46.80 47.85 49.70 51.15 52.85
M534	5 dia. x 3-1/2 wide Std. holes 5/8, 1/2 Max. safe rpm. 5500	37.80	3-1/2 x 15-1/2 50/unit	100F 80 60	70.55 71.80 73.75
M535	5 dia. x 3-1/2 wide Std. holes 518.11, 1/2.13	37.80	10 bands $10.00 net	50 40	75.60 77.55
M3270	3-1/4 dia. x 7 wide Std. hole 5/8-11 Max. safe rpm. 3500	70.00	7 x 10-11/16 50/unit 10 bands $10.20 net	100F 80 60 50 40	69.95 71.65 74.40 76.50 79.25

FIGURE 2.22: Grinding Accessories by Merit. Nu-matic air inflated wheels provide a resilient cushion of air that adapts to the contour of the work surface. Positive safety, too. No band slippage; no danger of flying parts.

Nu-matic wheels are available in a complete range of sizes from 2-½" to 10" in diameter. Heavy duty drums with standard or serrated surface are also available. Write for complete brochure for other sizes and details.

TYPES 16, 17, 18, 18R, and 19– Cones and Plugs —use with horizontal grinders *only.*

Driving flange (or cone spacer) must be flat, unrelieved —and must measure at least one-third the diameter of the cone or plug.

Examine driving flange – look for nicks, burrs, and other flaws.

Cone or plug must bear firmly against blotter and driving flange or cone spacer.

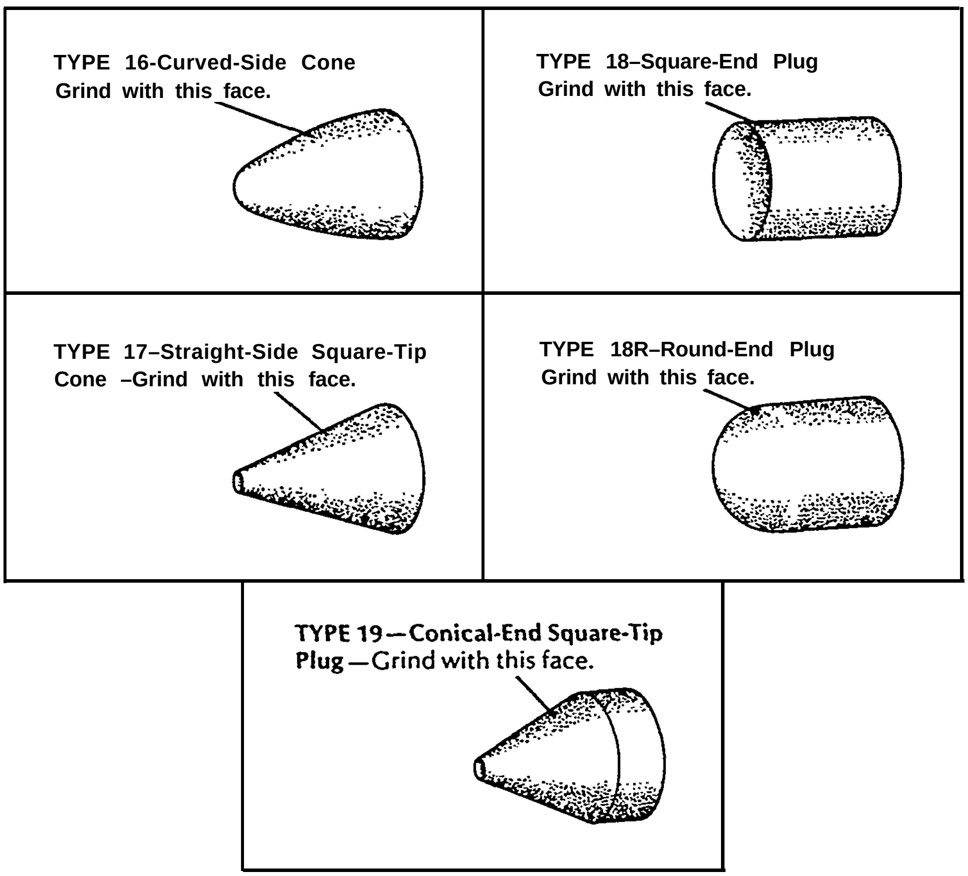
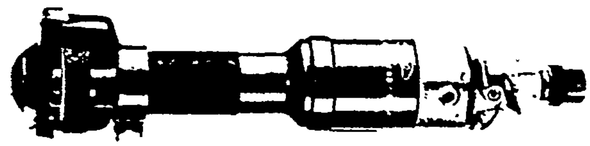
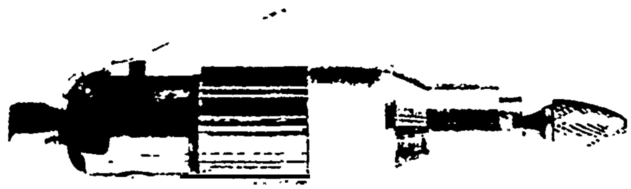


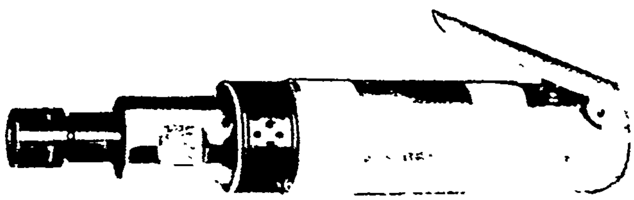
FIGURE 2.23: Grinding Wheels by Cleco.



214-A



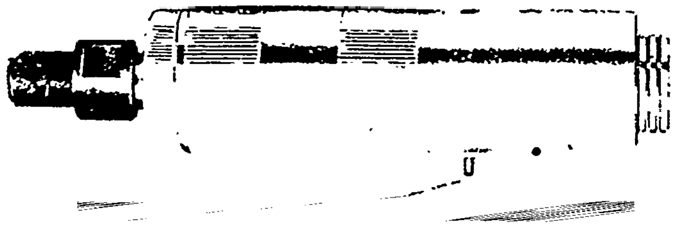
11-GLF-250

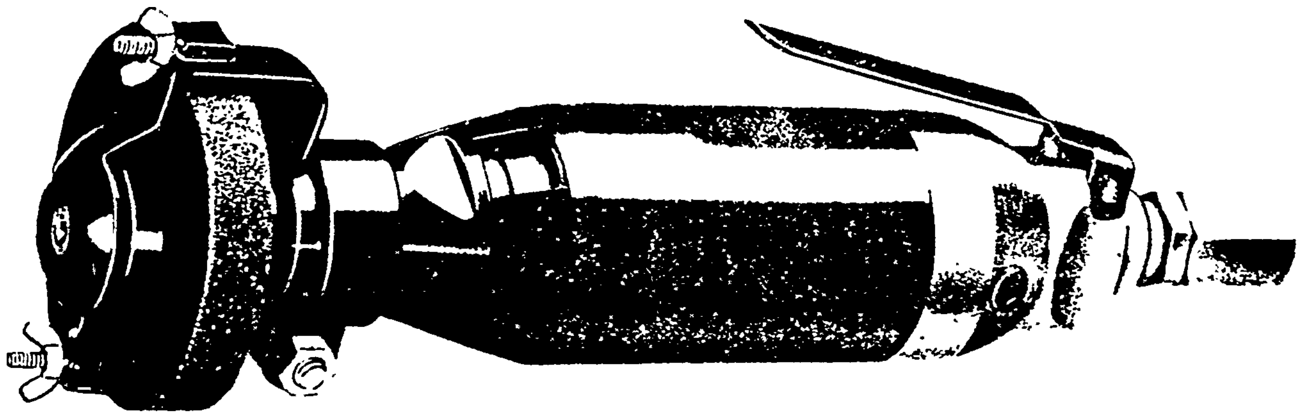


G160EF1

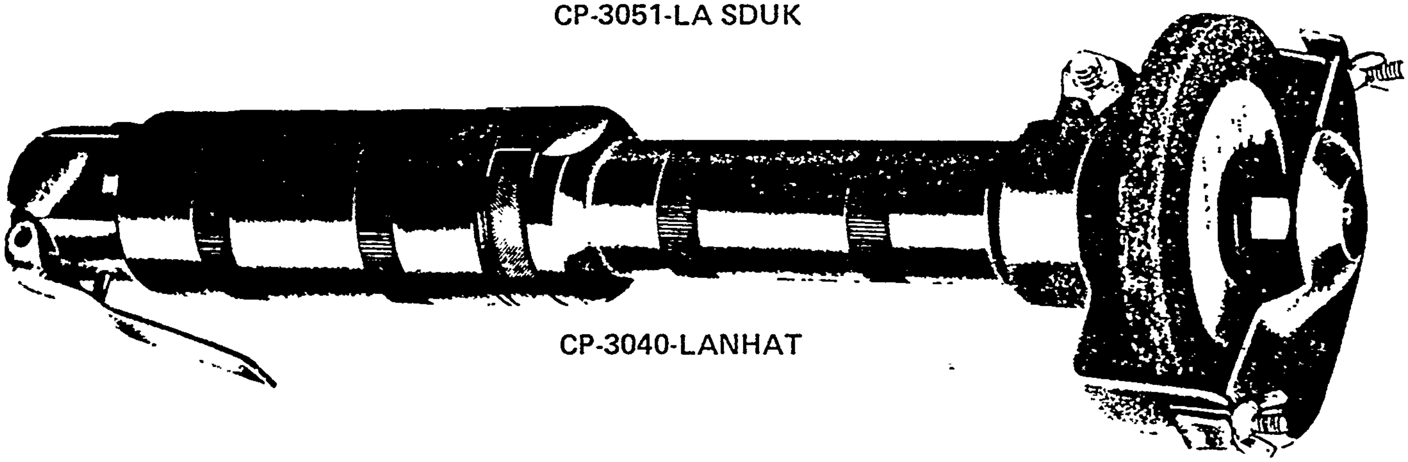
Tool : DIE GRINDER			
Manufacturer:	CLECO	CLECO	ING-RAND
Model:	214-A	11-GLF-250	G160EF1
Speed:	14,000	25,000	17,000
Weight:	3½ lb.	1 lb. 10 oz.	1-15/16 lb.
Length:	11¼"	5-5/8"	8-9/16"
Arbor Size:	3/8"-24	3/8"-24	¼"
Power:	Air	Air	Air
Inlet Size:	¼"	¼"	¼"
Outlet Size:	¼"	¼"	3/8"
Wheel Capacity:	2½"	—	

FIGURE 2.24: Die Grinders.





CP-3051-LA SDUK

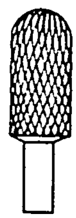


CP-3040-LANHAT

Tool: DIE GRINDER			
Manufacturer:	ING-RAND	CHI PNEU	CHI PNEU
Model:	G120CF1	CP-3051- LA SDUK	CP-3040- LANHAT
Speed:	25,000	12,000	25,000
Weight:	13/16 lb.	3-3/4 lb.	3 lb.
Height:	5-3/4"	10-5/8"	12"
Arbor Size:	¼"	3/8"-24	3/8"-24
Power:	Air	Air	Air
Inlet Size:	1/8"	¼"	¼"
Outlet Size:	¼"	3/8"	3/8"
Wheel Capacity:	—	3"	3"

FIGURE 2.25: Die Grinders.

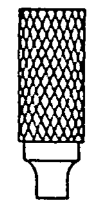
CYLINDRICAL RADIUS END



SCTI* Designation	Size	Code No. ¼ In. Shank	½ In. Shank
SC14	3/16 x 5/8 in.	869033	...
...	1/4 x 5/8 in.	889127	..
SC2	5/16 x 3/4 in.	889035	.
SC3	3/8 x 3/4 in.	889036	. .
SC5	1/2 x 1 in.	889038	...
SC6	5/8 x 1 in.	889039	889146
SC7	3/4 x 1 in.	889040	.

*Solid Carbide Tool Institute

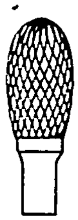
CYLINDRICAL PLAIN



SCTI* Designation	Size	Code No. ¼ In. Shank	½ In. Shank
SA14	3/16 x 5/8 in.	889003	...
	1/4 x 3/4 in.	889121	. .
SA2	5/16 x 3/4 in.	889005	...
	3/8 x 1/2 in.	889122	. .
SA3	3/8 x 3/4 in.	889006	...
	1/2 x 1/2 in.	889123	..
SA5	1/2 x 1 in.	889008	889141
SA6	5/8 x 1 in.	889009	..
SA16	5/8 x 3/4 in.	889011	889143

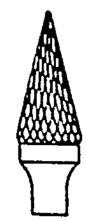
* Solid Carbide Tool Institute.

OVAL



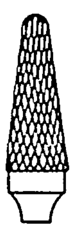
SE1	1/4 x 3/8 in.	889056	...
SE3	3/8 x 5/8 in.	889057	. .
SE5	1/2 x 7/8 in.	889058	
SE6	5/8 x 1 in.	889059	889161
SE7	3/4 x 1 in.	889060	..

CONE OR TAPER



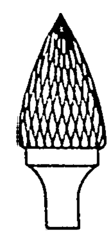
SM2	1/4 x 3/4 in.	889108	..
SM4	3/8 x 3/4 in.	889132	...
SM5	1/2 x 7/8 in.	889133	...
SM6	5/8 x 1 in.	889112	...

CONE ROUND ENO 14”



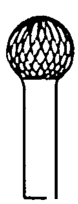
	1/4 x 5/8 in.	889135	
SL2	5/16 x 3/4 in.	889101	
SL3	3/8 x 1 1/16 in.	889102	. .
SL4	1/2 x 1 1/8 in.	889103	889163
SL7	3/4 x 1 1/2 in.	889106	889165

TREE POINTED



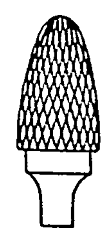
	1/4 x 3/4 in.	889129	. .
SG3	3/8 x 3/4 in.	889080	..
SG5	1/2 x 1 in.	889082	...
SG6	5/8 x 1 in.	889083	...
SG7	3/4 x 1 in.	889084	...

BALL

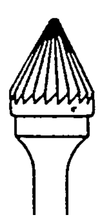


SD14	3/16 in.	889045	...
SD1	1/4 in.	889046	...
SD2	5/16 in.	889047	...
SD3	3/8 in.	889048	...
SD5	1/2 in.	889050	889166
SD6	5/8 in.	889051	..

TREE RADIUS END



	1/4 x 3/4 in.	889128	
SF3	3/8 x 3/4 in.	889064	.
SF5	1/2 x 1 in.	889067	889148
SF6	5/8 x 1 in.	889068	889149
SF7	3/4 x 1 in.	889069	.
SF14	3/4 x 1 1/4 in.	.	889151
SF15	3/4 x 1 1/2 in.	889071	889152

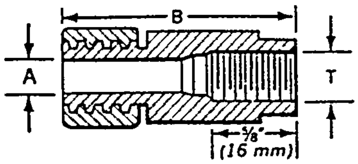


TAPER OR CONE 60°

SJ5	1/2 in.	889088	...
SJ9	1 in.	889092	...

FIGURE 2.26: Precision-Type Carbide Burrs for Die Grinders.

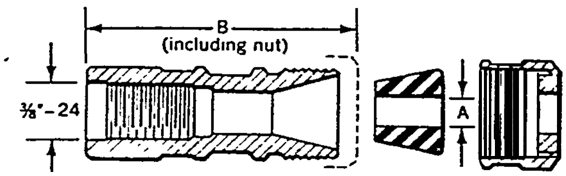
JACOBS® HEAVY-DUTY COLLET CHUCKS



*Super-duty

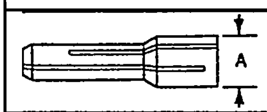
Part No.	Mounting Thread T	Capacity A in. (mm)	Length B in. (mm)
S-066271	⅜"—24	¼ (6.3)	1-11/16 (43)
C-069969		¼ (6.3)	3-9/32 (83)
C-104864*		¼ (6.3)	1-15/16 (49)
S-077292		⅜ (9.5)	1-11/16 (43)
S-081299		½ (12.7)	2¼ (57)
C-104636	½"—13	¼ (6.3)	2 (51)
C-104637		⅜ (9.5)	2⅛ (54)
C-104638		½ (12.7)	2-5/16 (59)

JACOB & RUBBER-FLEX COLLET CHUCKS



Chuck and Nut —Less Collet		Rubber-Flex Collets		
		Part	Capacity A, in. (mm)	
Part No.	Length B (mm)		Nominal	Actual
		C-042514	⅛ (3.2)	.094-.146 (2.38—3.71)
C-042512	1⅞ (48)	C-042515	3/16 (4.8)	.146—.198 (3.71—5.03)
C-042513	3-15/32 (88)	C-042516	(6.3)	.198—.250 (5.03—6.35)

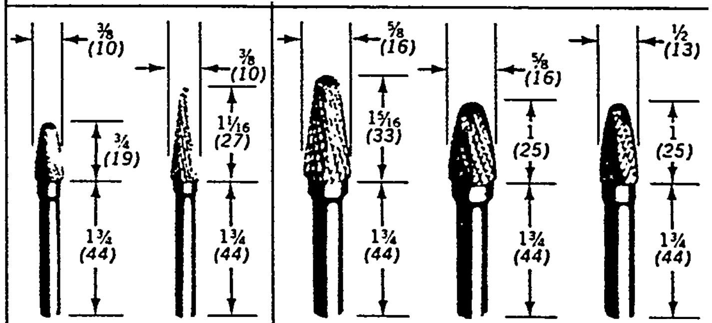
COLLETS FOR DIE GRINDER CHUCKS



Used with	Capacity A in. (mm)	Part No.
CP-9113 and CP-9113-ES	⅜ (10)	C-119730
	¼ (6)	C-119729

CARBIDE BURRS—All dimensions in inches *(millimeters)*

¼" (6.3 mm) SHANK | ⅜" (9.5 mm) SHANK

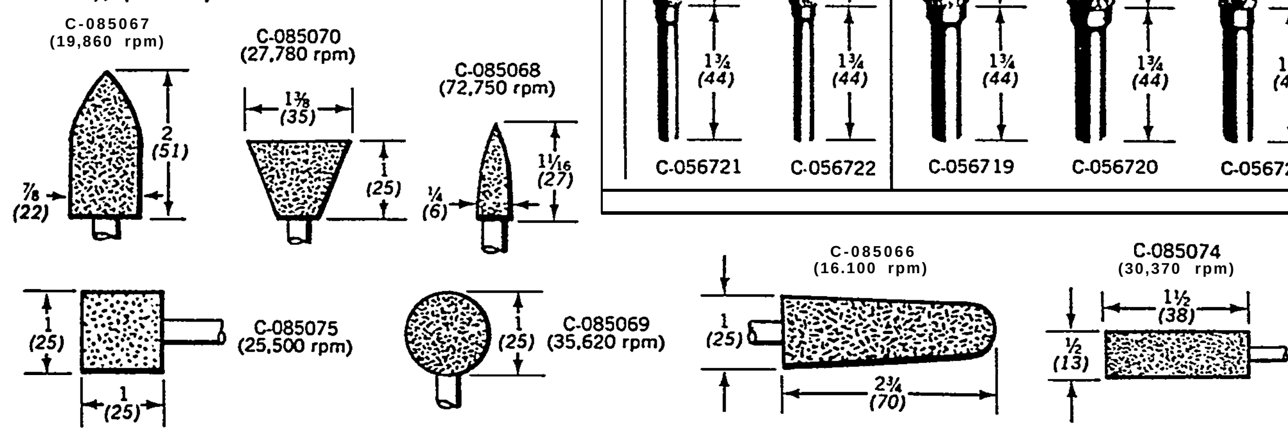


C-056721 C-056722 C-056719 C-056720 C-056723

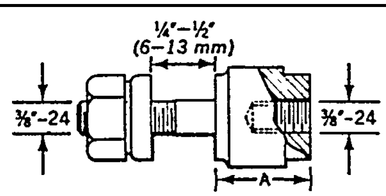
GENERAL-PURPOSE MOUNTED WHEELS

All dimensions in inches (millimeters)

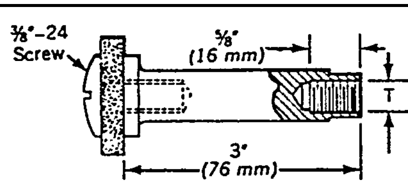
All wheels have ¼" *(6.3 mm)* diameter shanks and may be operated up to the maximum allowable speeds indicated providing overhang does not exceed ½" *(12.7 mm)*. Use with Jacobs® ¼" *(6.3 mm)* collet chucks.



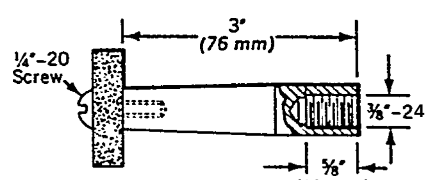
SPINDLE ADAPTERS



C-088130 Spindle Adapter "A" = ¾" *(19 mm)*
C-086726 Spindle Adapter "A" = 1¾" *(44 mm)*
Takes ⅜" *(9.5 mm)* arbor hole straight wheels ¼" to ½" *(6–13 mm)* thick.



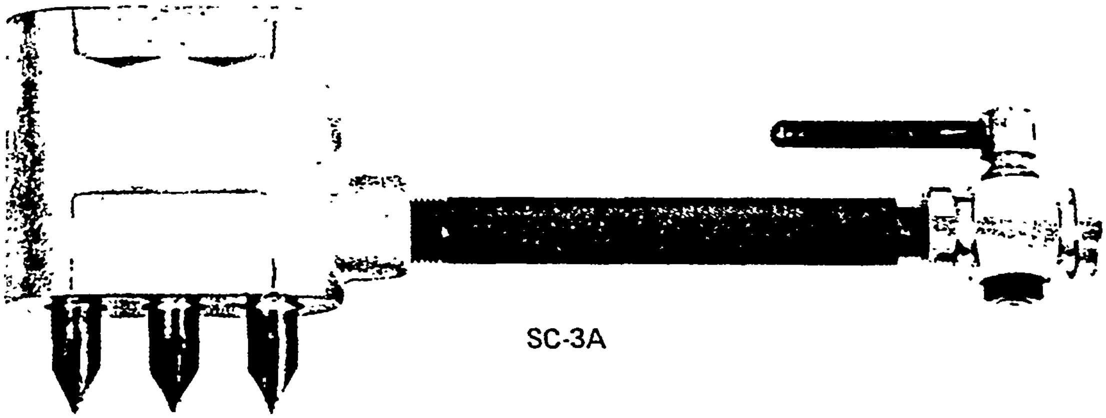
C-099018 mounting thread "T" = ⅜"—24.
C-104651 mounting thread "T" = ½"—13.
Spindle Adapter takes ⅜" *(9.5 mm)* arbor hole straight wheels ¼" to ½" *(6—13 mm)* thick.



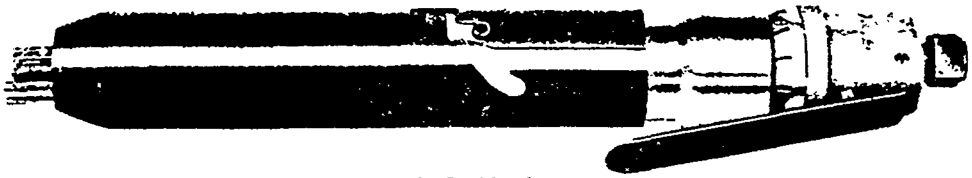
C-086722 Spindle Adapter takes ¼" *(6.3 mm)* arbor hole straight wheels ¼" to ½" *(6—13 mm)* thick.

FIGURE 2.27: Die Grinder Accessories by Chicago Pneumatic Tool.

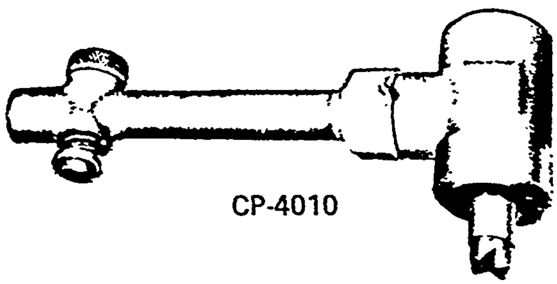
2.7.2 DESCRIPTION AND MODELS



SC-3A



172LNA1



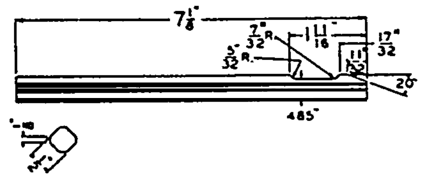
CP-4010

Tool:	TRIPLE SCALER	NEEDLE SCALER	PISTON SCALER
Manufacturer:	CLECO	ING-RAND	CHI-PNEU
Model:	SC-3A	172LNA1	CP-401O
Bore:	7/8"	15/16"	7/8"
Stroke:	13/16"	9/16"	½"
Blows/min.:	5200	5500	7000
Weight:	7 lb. 14/16 oz.	5¼ lb.	3-¾ lb.
Length:	13¼"	13-¾"	—
Power:	Air	Air	Air
Inlet Size:	3/8"	¼"	3/8"
Outlet Size:	3/8"	5/16"	—

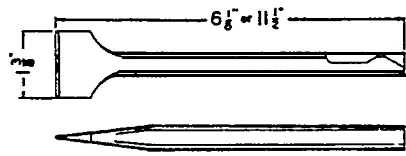
FIGURE 2.28: Scalers.

2.7.2.1 Accessory Description

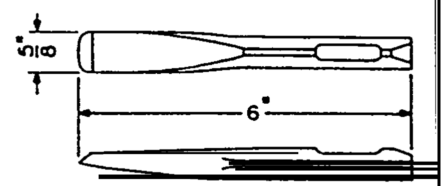
CHISELS



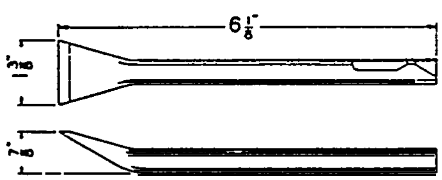
No. WF-14-7⅛ CHISEL BLANK



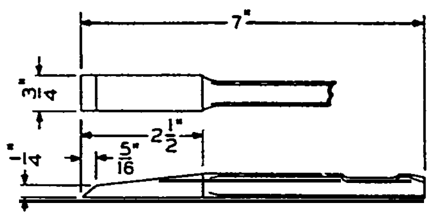
No. WF-14B-6⅛ or No. WF-14B-11½
STRAIGHT SCALING CHISEL



No. WF-14G-6 GOUGE CHISEL

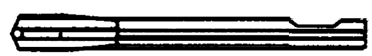


No. WF-14A-6⅛ ANGLE SCALING CHISEL



No. WF-14F-7 FLAT SCALING CHISEL

STAR DRILLS



CATALOG NO.	DIAMETER		LENGTH	
	In.	mm	In.	mm
WF-114-⅜	⅜	10	6½	165
WF-114-½	½	13	6½	165
WF-114-⅝	⅝	16	9	229
WF-114-¾	¾	19	9	229
WF-114-⅞	⅞	22	9	229
WF-114-1	1	25	12	305
WF-114-1⅛	1⅛	29	12	305

REPLACEMENT NEEDLES

CATALOG NO.	TYPE	PACKAGE
NS11-22 NS11-B22 NS11-S22	Alloy Steel Bery. Copper Stainless	19 Required for Complete Set

NEEDLE SCALER ATTACHMENT

ATTACHMENT	DESCRIPTION	
NS11A	Steel Needles	Round Needle Housing
NS11AB	Beryllium Copper Needles	
NS11AS	Stainless Steel Needles	
NS11A7	7" (178 mm) Extended Steel Needles	
NS11 B	Steel Needles	Rectangular Needle Housing
NS11B3	Beryllium Copper Needles	
NS11B5	Stainless Steel Needles	
NS11B7	7" (178 mm) Extended Steel Needles	

FIGURE 2.29: Scaler Accessories by Ingersoll-Rand.

2.8 Chipping Hammers

The chipping hammer resembles the scaler, and it is used in much the same manner. The resulting impact is very noisy; to date, not much has been done to solve this problem. The effectiveness of the tool is satisfactory, but production is rather slow.

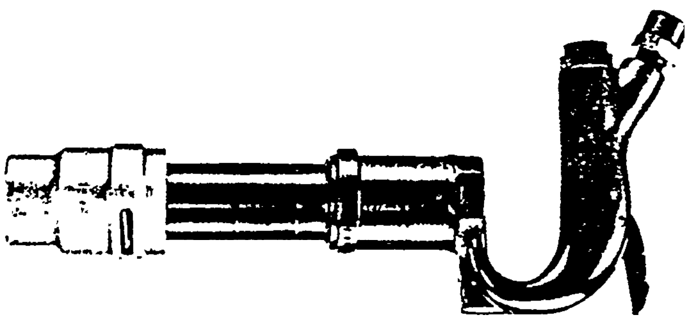
2.8.1 APPLICATIONS

Chipping hammers are most effective for the following operations.

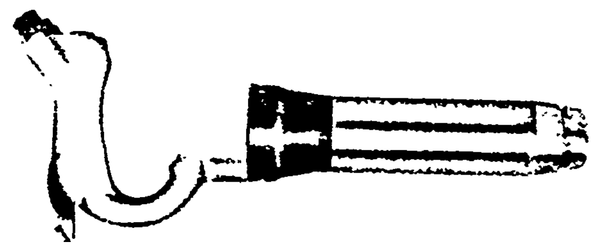
1. Caulking seams on ship shells.
2. Chipping and peening.
3. Removing weld flux, paint and rust.

2.8.2 DESCRIPTION AND MODELS

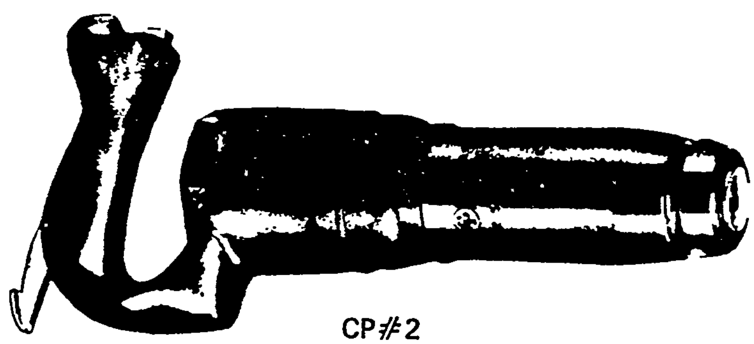
Figure 2.30 presents some commonly encountered chipping hammers and manufacturers' data.



OW-BD



4AIS



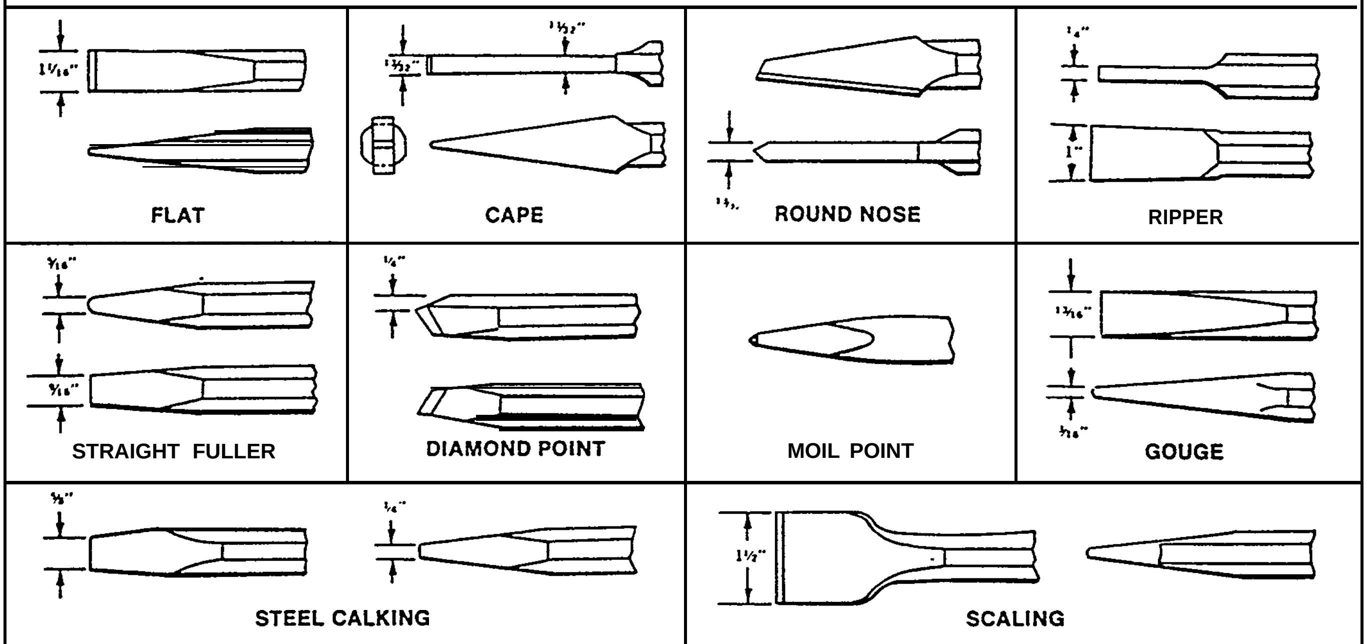
CP#2

Tool: CHIPPING HAMMER			
Manufacturer:	**CLECO**	**ING-RAND**	**CHI PNEU**
Model:	**OW-BD**	**4AIS**	**CP#2**
Bore:	15/16"	1-1/8"	1-1/8"
Stroke:	3"	4"	2"
Blows/min.:	3500	1480	2400
Weight:	6 lb.	15½ lb.	13 lb.
Length:	11-3/4"	16-7/8"	12-7/8"
Power:	Air	Air	Air
Inlet Size:	3/8"	1/4"	1/4"
Outlet Size:	3/8"	1/2"	—

FIGURE 2.30: **Chipping Hammers.**

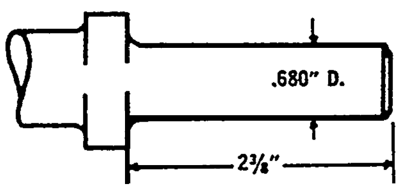
2.8.2.1 Accessory Description

CHISEL DIMENSIONS

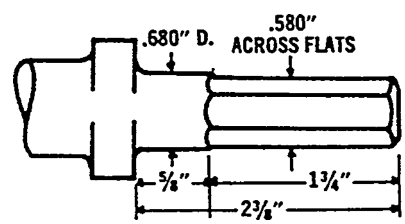


ROUND SHANK CHISELS (for use with Chippers equipped with Round Nozzle)

Length in.	Length mm	Chisel Part Number: Blank	Flat	Moil Point	Scaling	Diamond Point	Cape	Gouge	Round Nose	Straight Fuller	Calking	Ripper
12	305	HH1-215-12	HH1-215F-12	HH1-215M-12	HH1-215B-12	HH1-215D-12	HH1-215C-12	HH1-215G-12	HH1-215N-12	HH1-215J-12	HH1-215E-12	HH1-215R-12
18	457	HH1-215-18	HH1-215F-18	HH1-215M-18								
24	610	HH1-215-24	HH1-215F-24	HH1-215M-24								
36	914	HH1-215-36	HH1-215F-36	HH1-215M-36								



Note: All Chisels equipped with Oval Collars.



HEXAGON SHANK CHISELS (for use with Chippers equipped with Hex Nozzle)

Length in.	Length mm	Chisel Part Number: Blank	Flat	Moil Point	Scaling	Diamond Point	Cape	Gouge	Round Nose	Straight Fuller	Calking	Ripper
12	305	HH1-214-12	HH1-214F-12	HH1-214M-12	HH1-214B-12	HH1-214D-12	HH1-214C-12	HH1-214G-12	HH1-214N-12	HH1-214J-12	HH1-214E-12	HH1-214R-12
18	457	HH1-214-18	HH1-214F-18	HH1-214M-18								
24	610	HH1-214-24	HH1-214F-24	HH1-214M-24								
36	914	HH1-214-36	HH1-214F-36	HH1-214M-36								

FIGURE 2.31: Chipping Hammer Accessories by Ingersoll-Rand.

SECTION 3
ABRASIVE BLASTING

3. ABRASIVE BLASTING

3.1 General Findings

Today's shipbuilding technology dictates that the greater percentage of surface preparation be accomplished by abrasive blasting,of sheets and structural prior to fabrication and surface preparation, with subsequent coating in the modular stage prior to erection.

This change in methodology has been reflected in the modernization programs initiated by yards in the United States. Most yards have some form of closed-cycle blasting, whether it be plate, structural or modular, or a combination of these types.

Open abrasive blasting is still being used to a considerable extent, in some yards more than in others. Its major applications are structures, exterior hulls, deck houses and decks. If shop primers are used, they are generally removed by abrasive sweeping after erection. Open abrasive blasting is used to repair burned and damaged paint areas in tanks and ship exteriors, and it remains the major method of surface preparation in repair yards.

The project survey found that the major concerns of most yards are the identification of improved lighting systems and the need for effective grit removal equipment for use inside tanks and confined areas and on drydock floors. Some yards, it was found, are using a vacuum system to pick up grit or shot after blasting. These systems can be purchased in a variety of sizes. A multiple of long hoses can be attached to each unit.

While the project's prime objective was to survey attendant support equipment rather than to evaluate abrasive blasting equipment per se, this section also discusses the basic criteria for efficient abrasive blasting.

3.2 Closed-Cycle Blasting

Due to modernization, closed-cycle blasting is used by shipyards in varying degrees. Concern for environmental regulations and the potential savings this method offers will further increase its applications. Although progress has been somewhat hindered by a lack of availability of efficient equipment for specialized applications, manufacturers are realizing the potential market and increasing their development efforts. If these trends continue, shipyards of the future may become completely dependent on closed-cycle equipment.

3.2.1 PLATES AND STRUCTURAL

United States shipyard modernization programs have brought automatic closed-cycle blasting and paint lines for plates and structural to many yards. The following companies make closed-cycle blasting equipment for this application.

1. Wheelabrator-Frye
   Material Cleanings Systems Division
   451 South Byrkit Street
   Mishawaka, Indiana 46544
2. Pangbom
   Division of the Carborundum Company
   P. O. Box 380
   Hagerstown, Maryland 21740
3. **Vacu-Blast**
   P. O. Box 545
   Abilene, Kansas 67410
4. Metal Improvements Company, Inc.
   Peenmatic Division
   472 Barell Avenue
   Corelstad, New Jersey 07072

3.2.2 MODULES

Closed-cycle blasting houses for modules must be tailored to the individual yard's requirements in accordance with basic efficiency criteria. The following companies are designers of such systems.

1. Key Engineering
   1231 Shadowdale
   Houston, Texas 77043
2. Pangborn
   Division of the Carborundum Company
   P. O. Box 380
   Hagerstown, Maryland 21740
3. Vacu-Blast
   P. O. Box 545
   Abilene, Kansas 67410
4. Wheelabrator-Frye
   Material Cleanings Systems Division
   451 South Byrkit Street
   Mishawaka, Indiana 46544

3.2.2.1 Staging Area

A fully covered staging area must be provided, to be used for drying off, staging, picking up grindings and making any needed repairs. This area must be heated, or a localized method must be provided to dry the units prior to their entrance into the blast area. The surface tempera-

ture of the units must be above the dew point of the blast area. While the problem is minimized if the blast area is heated, the large volume of make-up air required may make this method not economically feasible.

Limited capacity overhead hoists are valuable in the staging operation.

Staging should be so designed as to minimize retention of abrasives. Chain link types of materials are useful for this purpose.

Electricity and/or air power should be provided for hand tools.

3.2.2.2 Transportation

It is advantageous in most cases, to provide some type of ground transportation which can place and shift the assemblies through the blast and paint facility. Rail appears to be the most preferred method, as it offers the following advantages.

1. Increased flexibility in scheduling maintenance and service for the building.
2. Reduced building and ventilation costs because the area needed is smaller than that required for a crane.

3.2.2.3 Abrasive Recovery and Processing Equipment

The prime objective of abrasive recovery and processing equipment design is to minimize the amount of shot required to operate the system. At $200.00/ton, the savings to be realized by reducing the quantities of shot required are evident. Reduction becomes all the more critical in view of the possibility that large quantities of shot may be lost through being contaminated by moisture as a result of the failure of some system component. To prevent the wasting of shot, a fast and efficient floor recovery and shot process system is required.

In evaluating such a system, the first step is to determine the amount of abrasives delivered per unit of time when the system is operating at full capacity. The second step is to determine the time it takes the system to recover and process the shot for reuse. Some designers claim that their floor recovery system will accomplish this process in continuous cycles of less than 3 minutes.

In the project survey of shipyards with such closed-cycle blast systems, one point clearly emerged: mechanical recovery systems are superior to vacuum types. Vacuum systems become clogged with debris picked up with the shot–paper, cigarettes, welding rods–resulting in increased downtime.

Abrasive processing equipment should be isolated from the abrasive blast area. The area containing this equipment should be heated to insure that the equipment and the shot are above the dew point, thus preventing moisture condensation. A vacuum recovery system should be provided for removal of the abrasives trapped in the modules. This system should return the abrasive to the processing system.

3.2.3 SHIP'S HULL AND DECK

Surface preparation of the hull and deck areas, as well as of the ship's tanks, is still being done almost exclusively by open abrasive blasting in the United States. Because of environmental concern and the spiraling cost of abrasives, however, manufacturers and yards are becoming increasingly interested in the development of closed-cycle blasting equipment to meet requirements in these areas. Companies have developed blasting heads and shot recycling units that are capable of efficiently blasting flat surfaces. Problems still remain to be solved in the blasting of contoured surfaces and in equipment handling.

Available closed-cycle blasting systems have been field tested by the Plant Engineering Department of Avondale Shipyards, Inc.

3.2.3.1 Vacu-Blast

The Vacu-Blast shipside and bottom blast system, developed with Marine Administration funding, was evaluated.

The trailer transporter was found to have very poor mobility because of its bulk and the low (1-½" - 2") clearance between the iacks and the road. The keel blocks and the thwart ship support configuration, on both the building ways and the drydock, made it impossible to utilize the equipment. Representatives from new construction and repair yards examined the equipment and reached similar conclusions.

3.2.3.2 Nelson International Marine Service, Inc. System

The Nelson system depends on a cable and trolley system for movement. Difficulty was experienced with both the vertical lift cable and the horizontal cable which controls the amount of pressure exerted by the head on the surface. The resulting tilting of the head caused non-uniform horizontal' travel. As a result, the quality of cleaning was very erratic. Modifications failed to correct these problems.

While problems exist with the Nelson hull unit, the company makes closed-cycle abrasive blast equipment which has been effectively used to blast large deck areas, such as those on Navy carriers.

3.2.3.3 Wheelabrator Mobile Blasting Machine

This Wheelabrator machine was developed under Navy contract. It was demonstrated at the Long Beach Naval Shipyard. The blasting head performed effectively, but handling the equipment is cumbersome and does not seem adaptable to modification.

An old paint system was removed to obtain a near-white blast. Blasting rates of 720 - 960 sq. ft./hr. were obtained. The blasting head sweeps a 48" pattern and can be pivoted up 1°, down 45° and left and right 45°.

The machine is being shipped to Avondale Shipyards, Inc. for further evaluation.

3.2.3.4 Texstar, Inc. Automatic De-scaling Equipment

Texstar's Magstar machine performed effectively, descaling mild rust and removing inorganic shop primer from the LNG. Some rework of the heavier rusted weld areas was required. It was determined that the machine would not be as effective on the lapped riveted joints that may be required in a repair yard or on the contoured areas of a ship's bow and stern.

A Link Belt Crawler Crane with two 130' booms was utilized for handling the machine during blasting. A lineal travel speed of 5-8 ft./min. was obtained, resulting in a blast rate of 1,000 sq. ft./hr. A 3" overlap blasting pattern was used.

It was calculated that a meaningful cost savings would result if the automatic equipment was used, as an alternative to manual blasting, on a ship of the LNG size and configuration.

3.2.3.5 Future Development

Avondale Shipyards, Inc. is proceeding in the development of an automatic blasting and paint system for ship hulls. It is projected that a Wheelabrator blasting head, when adapted to a Heede staging system, would be capable of blasting 90% of a ship's vertical hull of the LNG design, including most of the compound curves of the bow and stern areas. An automatic paint head developed by Binks will be utilized with the same handling equipment for the coating application.

3.2.4 SPECIAL APPLICATIONS

Numerous yards are familiar with Vacu-Blast cup-type closed-cycle blasting equipment, available in numerous sizes and capacities. Some of the smaller units have been tried on master butt weld preparations. The concensus is that blast rates were too slow to do an efficient job on more heavily rusted areas and welds. Some of the larger Vacu-Blast units have been modified to some degree. They have been used efficiently for specialized applications, such as the use of a dual cup in conjunction with an automatic T-beam weld line to remove slag from the weld.

Two other applications for the equipment occur in web frame fabrication. In the first, cup is placed in a permanent vertical position on a conveyor, and the webs are then pushed manually through a guide past the cup. The cup removes the shop primer on the edge to be welded. In the second application, the primer is removed from the area of plate to which the web is to be welded. The cup, mounted on wheels, is pushed across the plate in the horizontal position. A 3" cup is used for these applications.

Figure 3.1 depicts a typical Vacu-Blast system.

3.2.5 ABRASIVES

In closed-cycle blasting, the economy and performance of the blast cleaning operation is primarily a function of the abrasive used. To attain maximum economy and efficiency, it is important to select the proper size and type of abrasive.

To be truly efficient, an abrasive must both clean rapidly and yield a high quality finish at minimum operating cost. Three major factors determine how well an abrasive meets these requirements: (1) breakdown characteristics, (2) hardness and (3) size. Each of these factors must be carefully evaluated when determining the best abrasive to use in blast cleaning equipment.

3.2.5.1 Breakdown Characteristics

An abrasive's breakdown characteristics are of primary importance in determining blast cleaning performance and economy. They have tremendous influence on abrasive cost, on the wear and subsequent maintenance costs of parts and on the finish imparted by the blast operation. Because wear on abrasive pellets is negligible, it is not a factor in abrasive size reduction. Rather, abrasive size reduction is caused by fatigue of the pellet structure and its ultimate fracture into smaller

fragments. Each abrasive, because of the basic structure it derives from the chemistry, metallurgy and manufacturing processes, has inherent fatigue qualities which govern its breakdown characteristics in blast cleaning equipment.

In closed-cycle blast cleaning equipment, abrasive pellets are thrown from a rapidly rotating bladed wheel (or from an air blast nozzle) at extremely high velocity. They impinge on the work surface, performing the basic job of cleaning away sand, scale or other contaminants or of peening the surface to improve fatigue life. The pellets then are automatically collected, cleaned of contaminants and recycled through the propelling mechanism.

At each impact on the work surface, the pellets are highly stressed and sustain a certain amount of damage through fatigue. Through continued recycling and repeated impacts, the fatigue damage to the pellet structure builds to a point where the pellet is overstressed, causing it to explode into many smaller particles. Further impacting of these abrasive fragments as they recirculate through the system causes them to ball up into smaller spheres; in time, these also explode into yet smaller fragments. This process is repeated until the pellets fracture into particles too small to be usable, whereupon they are removed from the system by the separator mechanism.

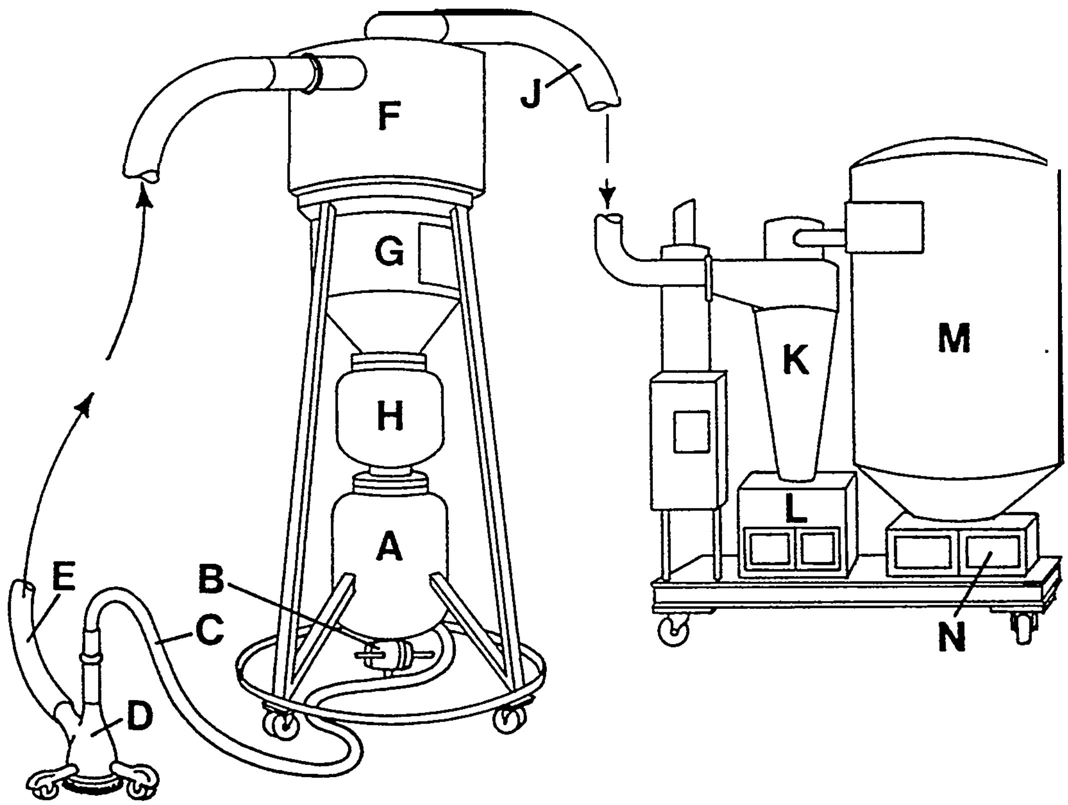


FIGURE 3.1: **Vacu-Blast Model C1OL with Dust Collector.**

Abrasive is metered, under pressure, from the generator (A) through the feed valve (B) to the blast hose (C). Compressed air carries the abrasive to the blast gun (D) where abrasive is accelerated through the nozzle towards **the work piece. Used abrasive, dust and debris from blast**ing is picked up and carried in a vacuum hose (E) to the reclaimer (F). In the reclaimer, the good abrasive falls to the air wash, screening section and storage hopper (G). Good abrasive is returned through the upper pressure generator (an air lock) (H) to recharge the blast generator (A). Air, fine dust and debris is drawn from the reclaimer through a hose (J) to the dust collector. The cyclone (K) (optional equipment) removes 95% of the carried particles within the air stream and deposits them in a dust box (L). The air then flows to the bag house (M); it removes the remaining fine dust which falls to a dust box (N). The clean air flows from the bag house to the vacuum **pump and is exhausted to the atmosphere.**

3.2.5.1.1 Abrasive *Costs and Consumption Rates*

The number of times an abrasive will cycle through the propelling unit before fracturing determines the amount of abrasive that will be consumed per blasting hour. This amount varies widely from one abrasive to another. For example; the consumption of chilled iron abrasives may be as high as 40 lbs./hr. when thrown by a wheel powered with a 20 h.p. motor. In the same operation, a highquality steel shot may consume as little as 6 lbs./hr. This consumption factor should be considered, along with the purchase price, to determine ultimate abrasive cost and economy.

Figure 3.2 displays the relationship of abrasive prices and consumption rates to actual costs.

3.2.5.1.2 *Wear and Maintenance of Parts*

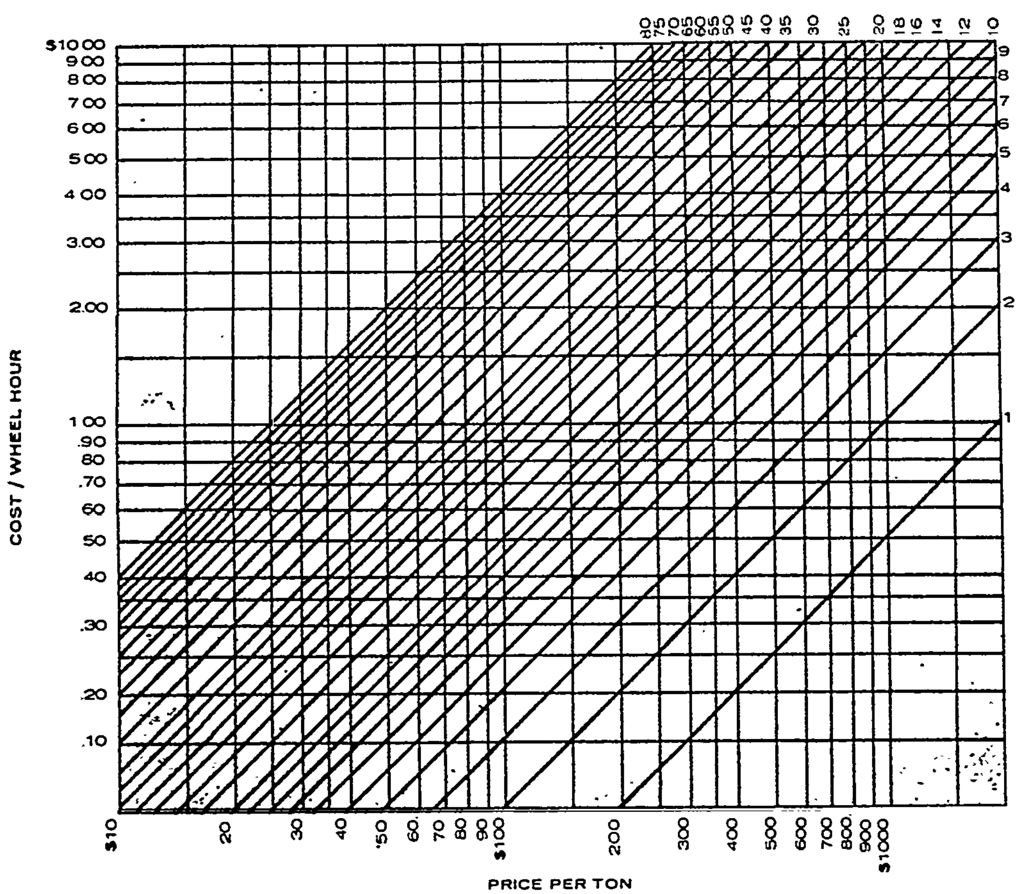
It has been fairly well established that the wear rate of parts in blast cleaning equipment is accelerated by the presence of sharp cutting edges in the operating mixture. Even the presence of small amounts of sand in an operating mixture will reduce the life of parts by 50 - 80%. Brittle ferrous grits, such as chilled iron, also substantially reduce the life of parts.

Since the breakdown rate of an abrasive determines the number of new sharp edges formed in an operating mix, it is also a major factor in determining the relative length of life of the parts. Thus, added benefits are achieved by using the most durable abrasives available.

3.2.5.2 Hardness

Abrasive hardness affects cleaning speed, abrasive rebound and the finish imparted to the work.

When abrasive pellets, moving at high velocity, strike the work surface, their kinetic energy, as imparted by the wheel, can be dissipated in many ways. Ideally, all of the kinetic energy of



COURTESY OF WHEELABRATOR CORP.

FIGURE 3.2: **Relationship of Abrasive Prices and Consumption Rates to Actual Costs.** Example: An abrasive with a price of $100.00/ton and a consumption rate of 22 lbs./wheel hour would cost $1.10/wheel hour; an abrasive with a price of $220.00/ton and a consumption of 7 lbs./wheel hour would cost only $0.77/ wheel hour.

the moving pellets should be transmitted to the work surface on impact, performing the useful function of removing sand, scale and other contaminants. In actuality, the instantaneous force at impact is so great that the yield point of the abrasive is exceeded. Thus, a portion of the energy is always dissipated in the permanent deformation of the abrasive pellet. This energy is wasted because it performs no useful function.

The amount of energy thus wasted is, to a large extent, governed by the hardness of the abrasive. The harder the abrasive, the greater its resistance to deformation and the greater the percentage of energy transmitted to the work surface.

Energy can also be wastefully dissipated by the fracturing of brittle pellets, with very little impact energy being transmitted to the work surface. Harder abrasives which resist deformation and fracturing can therefore clean appreciably faster than softer or more brittle abrasives. Added benefits are achieved by the greater elastic rebound of harder abrasives, which greatly increases their ability to clean hard-to-reach recesses and cored areas.

3.2.5.2 Size

When choosing the size of the abrasive to be used, two factors must be considered: the impact provided by the mass of the larger pellets and the relative coverage of the mix. Because coverage is critical to cleaning speed, it is best to use the smallest possible size for a particular job. For example, if pellets of size S-460 are large enough to remove the sand or scale on a given part, then an S-460 operating mix will clean faster and better than a mixture of a larger size (S-660, for example) because it will afford greater coverage.

The consumption rate of different sizes of the same abrasive in a given operation will be the same, as long as the removal size of the spent abrasive is smaller than the smallest size found in the newly added abrasive.

3.2.5.3.1 *Mixture of New and Used Abrasive*

Using the same type of abrasive as a constant, the abrasive consumption in any operation is determined by the removal size of the abrasive, and not by the size of the abrasive added, provided that no new abrasive is removed. Thus, the consumption of S-330, S-230 or S-170 would be the same in a blast cleaning operation where the spent abrasive is removed when it is .0083" in diameter.

In starting new operations, it is best to start with the smallest size estimated as practical, adding larger abrasive as necessary until the proper size range is found. When changing from one type of abrasive to another in an established operation, the mix can be screened to determine the proper working size range. Generally, because of differing breakdown characteristics, it is necessary to drop to the next smaller size when changing from a malleable shot to a steel shot, and to two sizes smaller when changing from a chilled iron to a steel shot. These steps help to maintain the same size range in the operating mixture and achieve the same basic finish.

3.2.5.3.2 *Particle Size Distribution Between New and Used Abrasive*

Efficient abrasive operating mixtures should contain large, medium and fine pellets. The large sizes do the heavy work of loosening contaminants from the work surface, and the finer abrasive particles do the lighter work of cleaning up after large particles have jarred the contaminants loose. The finer abrasive pellets also provide adequate coverage of the work and greatly increase cleaning speed.

Figure 3.3 illustrates the size distribution of an S-460 operating mixture, composed mainly of full-sized abrasive. Due to either a large addition of new abrasive, heavy carry-out of abrasive or removal of the fine abrasive pellets by the separator or dust collector, this mixture would give only 83,000 impacts/lb. when thrown by the wheel. It would clean very slowly, while giving the parts a coarse finish.

Figure 3.4 illustrates a good operating mixture of S-460 shot. The breakdown products of the full-sized pellets have been retained for their full life as a useful abrasive. The mixture would give over 550,000 impacts/lb. of abrasive thrown by the wheel and would clean rapidly with minimum cost.

3.2.5.4 Profiles

The surface finish required is dictated by the coating to be applied. If low-volume solid primers that normally apply at 1.5 mils per coat are used, the maximum profile obtained should not be in excess of 1.5 mils. If deeper profiles are obtained, spot rusting will occur, due to unprotected peaks. Deeper profiles may be used for heavier coatings. Most high-build tank coating suppliers require a minimum profile of 1.5 mils. It should be noted

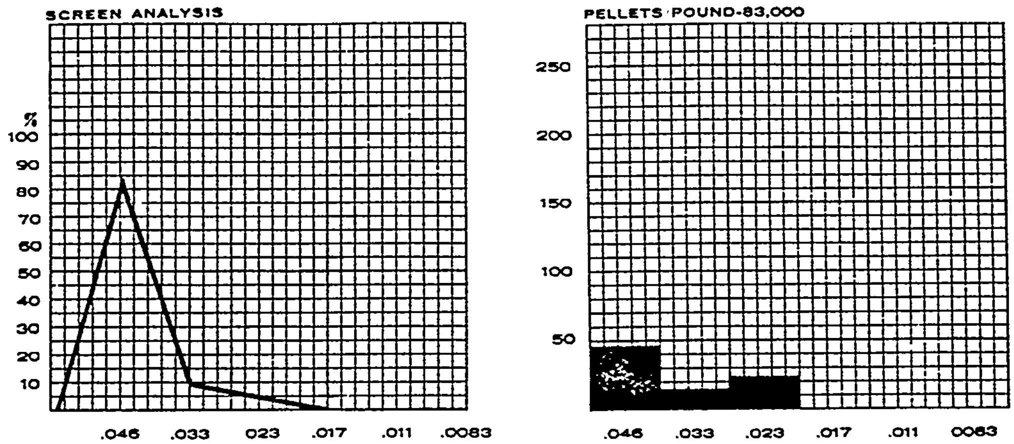


FIGURE 3.3: New Abrasive, S-460 Operating Mixture.

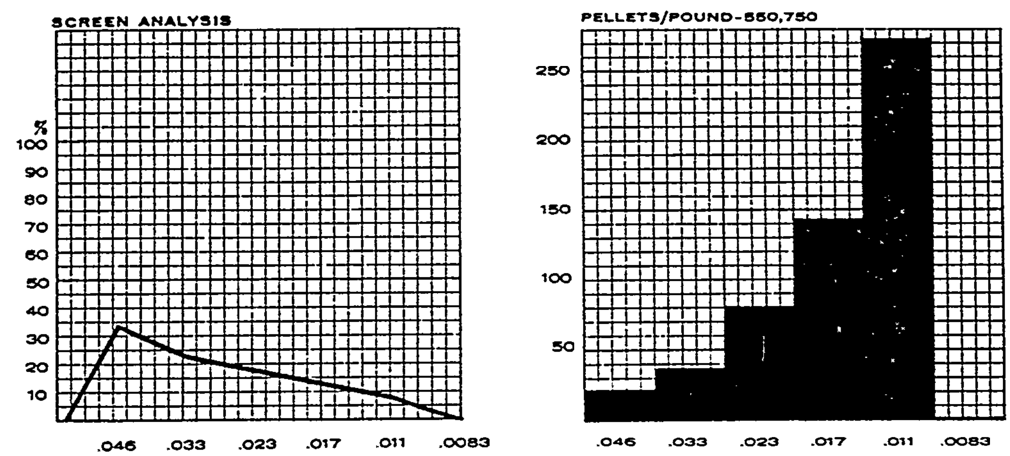


FIGURE 3.4: Old Abrasive, S-460 Operating Mixture.

COURTESY OF WHEELABRATOR CORP.

that excessive profile results in increased paint consumption because the profile must be filled before the required number of mils is obtained.

The type of profile obtained depends on the shape of the abrasive pellets in the blasting mix. A *shot finish* is a wave-like profile, while a *grit finish* is a jagged, etch-type profile. The *grit finish* is the profile most preferred for coating adhesion.

The same three abrasive properties that determine abrasive efficiency—breakdown characteristics, hardness and size—also interact to determine the type of finish produced.

The abrasive's breakdown rate is one of the major factors determining whether *shot* finish or a *grit* finish is achieved. All abrasives tend to become dull during use and to ball up under impact. To retain sharp edges in an abrasive operating mixture, new sharp edges must be continuously formed by the fracturing of the dulled pellets. It is these newly-formed sharp edges and angular shapes which impart an etched finish to the blasted surface.

Abrasive hardness is important also. Harder abrasives increase the depth and uniformity of surface penetration. This result is particularly important when special finishes are required for mechanical bonding of surface coatings. Hardness is also a key determinant of cleaning or etching speeds and production rates.

The size distribution of the operating mixture determines the relative roughness of the blasted surface. For general cleaning applications, it is desirable to use as small a size as possible, resulting in greater coverage and a smoother finish.

Figure 3.5 displays the typical maximum height of profile produced by various abrasive materials and sizes.

Abrasive	Maximum Particle Size	Maximum Height of Profile
Sand, very fine	through 80 mesh	1.5 mils
Sand, fine	through 40 mesh	1.9
Sand, medium	through 18 mesh	2.5
Sand, large	through 12 mesh	2.8
Steel grit, No. G-80	through 40 mesh	1.3 - 3.0
Iron grit, No. G-50	through 25 mesh	3.3
Iron grit, No. G-40	through 18 mesh	3.6
Iron grit, No. G-25	through 16 mesh	4.0
Iron grit, No. G-16	through 12 mesh	8.0
Steel shot, No S-170	through 20 mesh	1.8 - 2.8
Iron shot, No. S-230	through 28 mesh	3.0
Iron shot, No. S-330	through 16 mesh	3.3
Iron shot, No. S-390	through 14 mesh	3.6

FIGURE 3.5: Typical Maximum Profile Produced by Different Abrasive Materials and Sizes.

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3.2.5.5 Material

Tempered steel shot or grit is the most economical type of abrasive, based on cost and consumption rate, for closed-cycle blasting. This abrasive is available from numerous suppliers. The material procured should be sized to SAE shot specifications. Typical preferred hardness ranges are Rockwell C 45 - 51 for shot and Rockwell C 56-60 for grit. Other hardness ranges are available for special applications.

Figure 3.6 provides SAE shot and grit size specifications.

3.3 Open Blasting

Open abrasive blast cleaning is an efficient and widely used way of removing mill scale, rust, old paint and the like from surfaces to be painted. This method of surface preparation provides clean surfaces with an acceptable profile for coatings.

While open abrasive blasting is the most widely used method of surface preparation in the metal fabrication industry, many users have not established profit operations through careful analysis and the provision of proper equipment and methods. In order to maximize productivity and profits the following components are required.

1. Large compressor.
2. Large air hose and couplings.
3. Portable high-production sandblast machines.
4. Large-size sandblast hose with external couplings.
5. Large-orifice venturi nozzle.
6. Remote control valves.
7. Moisture separators.
8. High nozzle air pressure.
9. Proper sandblasting abrasive.
10. Air-fed safety helmets.
11. Operator training.

3.3.1 EUROPEAN PRACTICE

Europe has surface preparation and coating contractors who specialize in coating ships and ship tanks. The project surveyed a contractor which has accomplished higher blasting rates than those obtained by United States shipyards, without a reduction in quality or in the surface profile obtained. The higher rates were accomplished by careful job planning, excellent equipment and attention to the basic components of an efficient abrasive blasting operation.

The contractor's compressor equipment provided a large volume of high-pressure air. The air supply was designed with a dual dehumidification system to insure moisture-free air. This air, in combination with their dehumidification and ventilation equipment, maintained a near-white blast without flash-rusting for one week.

SAE Shot Size Specifications

Screen No.	Screen Size	Screen Opening Sizes and Screen Numbers with Max. and Min. Cumulative Percentages Allowed on Corresponding Screens — Shot Number 780	660	550	460	390	330	280	230	170	110	70
7	0.111	All Pass										
8	0.0937		All Pass									
10	0.0787	85% min		All Pass	All Pass							
12	0.0661	97% min	85% min		5% max	All Pass						
14	0.0555		97% min	85% min		5% max	All Pass					
16	0.0469			97% min	85% min		5% max	All Pass				
18	0.0394				96% min	85% min		5% max	All Pass			
20	0.0331					96% min	85°4 min		10% max	All Pass		
25	0.0280						96% min	85% min		10% max		
30	0.0282							96% min	85% min		All Pass	
35	0.0197								97% min		10% max	
40	0.0165									85% min		All Pass
45	0.0138									97% min		10% max
50	0.0117										80% min	
80	0.007										90% min	80% min
120	0.0049											90% min
200	0.0029											

SAE Grit Size Specifications

Screen No.	Screen Size	Screen Opening Sizes and Screen Numbers with Minimum Cumulative Percentages Allowed on Corresponding Screens — Grit Number G10	G12	G14	G16	G18	G25	G40	G50	G80	G120
7	0.111	All Pass									
8	0.0937		All Pass								
10	0.0787	80%		All Pass							
12	0.0661	90%	80%		All Pass						
14	0.0555		90%	80%		All Pass					
16	0.0469			90%	75%		All Pass				
18	0.0394				85%	75%		All Pass			
20	0.0331										
25	0.0280					85%	70%		All Pass		
30	0.0232										
35	0.0197										
40	0.0165						80%	70%		All Pass	
45	0.0138										
50	0.0117							80%	65%		All Pass
80	0.007								75%	65%	
120	0.0049									75%	60%
200	0.0029										70%
325	0.0017										

Average Number of Impacts Per Pound of Shot

S-780	S-660	S-550	S-460	S-390	S-330	S-280	S-230	S-170	S-110	S-70
11,400	19,200	32,000	55,000	93,000	153,000	250,000	420,000	1,200,000	3,400,000	12,000,000

FIGURE 3.6: SAE Shot and Grit Size Specifications. COURTESY OF WHEELABRATOR CORP.

Blasting pressures used were higher than those used in U. S. yards. 110- 115 psi air was used in small confined tanks with internal structural. 140 - 150 psi air was used in large tanks, such as wing and double bottom. The pressure was maintained by the use of 1/2" inside-diameter hose without whips and of high-wear venturi nozzles.

The efficiency of this high-volume/high-pressure blasting procedure was made evident by the low abrasive consumption rate of 8.2 lbs./sq. ft. and the high blasting rates obtained.

3.3.2 AIR SUPPLY

The compressed air supply is the most critical part of sandblasting, because work done is in direct proportion to its volume and pressure. Efficient sandblasting requires both high pressure (90 - 100 lbs.) and high volume of air 81-338 cfm. A 10 lb. loss of pressure at the nozzle means a 15% loss in production.

In addition to the volume and pressure requirements, the air must be dry or the freshly cleaned surface will flash-rust, when contaminated with moisture. Additionally, downtime will result from the clogging of equipment due to caking of the wet abrasive.

To ensure that the air at the nozzle is dry, each blast pot should have a moisture trap, in addition to the drying system associated with the **compressor.**

3.3.2.1 Air Flow and Sand Consumption as a Function of Nozzle Size

Figure 3.7 shows the air and sand consumption rates of sandblast nozzles at various pressures. It reflects air consumption rates which are considerably lower than those registered in the normal operation of air tools on a sandblast job–partly because it represents air which is carrying abrasive as well as free air.

Nozzle Diameter (inches)	Nozzle Pressure						
	50	60	70	80	90	100	
1/8	11.3	13.2	15.1	17.	18.50	20.25	cfm Air
1/8	67.	77.	88.	101.	112.	123.	Sand Used/Hr.
1/8	1.61	2.07	2.55	3.09	3.55	4.19	hp. Required
3/16	26.	*30.*	*33.*	*38.*	*41.*	*45.*	Air
3/16	150.	171.	196.	216.	238.	264.	Sand
3/16	3.56	4.59	5.51	6.92	7.87	9.32	hp.
1/4	47.	54.	61.	68.	74.	81.	Air
1/4	268.	312.	354.	408.	448.	494.	Sand
1/4	6.44	8.26	10.19	12.37	14.2	16.77	hp.
5/16	77.	89.	101.	113.	126.	137.	Air
5/16	468.	534.	604.	672.	740.	812.	Sand
5/16	10.55	13.62	16.87	20.56	24.19	28.36	hp.
3/8	108.	126.	143.	161.	173.	196.	Air
3/8	668.	764.	864.	960.	1052.	1152.	Sand
3/8	14.8	19.3	23.9	29.3	33.2	40.6	h.p.
7/16	147.	170.	194.	217.	240.	254.	Air
7/16	896.	1032.	1176.	1312.	1448.	1584.	Sand
7/16	20.1	26.0	32.4	39.5	46.1	52.6	hp.
1/2	195.	224.	252.	280.	309.	338.	Air
1/2	1160.	1336.	1512.	1680.	1856.	2024.	Sand
1/2	26.7	34.3	42.1	51.0	59.3	70.0	hp.

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FIGURE 3.7: AU F1OW and Sand Consumption as a Function of Nozzle Size and Pressure. The h.p. figure represents the electric motor horsepower required to produce the indicated cubic feet per minute (cfm).

3.3.3 HOSE

Hoses should be kept as short as possible to minimize pressure loss. The hose diameter used should be as large as possible given the available air capacity and the configuration of the structure to be blasted.

The training of operators to hold 1-1/4" hose rather than use a whip has recently been done by some shipyards and contractors, resulting in substantial increases in production. If the structure being blasted has numerous stiffners and angles, the addition of a 3/4" inside-diameter (id) whip may be required to improve flexibility and efficiency.

To minimize pressure losses, all couplings should be of the external type. Figure 2.1, in section 2, provides information which can be used to estimate amounts of pressure lost in hose of various sizes and lengths.

3.3.4 NOZZLES

Nozzles should be of a venturi design and should be as long as practical (up to 8") for the available work area.

3.3.4.1 Nozzle Material and Wear

Only tungsten carbide or norbide nozzles should be used. Tungsten carbide has approximately 300 hrs. of work life, while norbide yields 750 - 1,000 hrs. Nozzles should be discarded when worn because they cause a large loss of efficiency due to loss of pressure. This point was verified by a pressure test, conducted during this project, in which a nozzle pressure of 82 psi was measured on a worn nozzle. The continued use of the worn nozzle would have resulted in a loss of work efficiency of approximately 30%

Steel pipe should never be used as a nozzle because of the large pressure loss that results.

3.3.4.2 Nozzle Size

A nozzle with the largest orifice size possible should be used to fit the available air supply. The table which follows compares work obtained from different orifice sizes of venturi nozzles.

Nozzle Size/Work	Efficiency
1/4"	100%
3/16"	157%
3/8 "	220%
7/16"	320%
1/2"	400%

Example: If 100 sq. ft./hr. can be obtained with a ¼" nozzle, 400 sq. ft./hr. can be obtained with ½" nozzle.

3.3.4.3 Pressure Measurement

Throughout this discussion, reference has been made to the tremendous importance of high nozzle pressure in production blasting. Many users of abrasive equipment will insist that they are blasting with high pressures because the gauge on the compressor and/or the gauge on the sandblast machine is showing a high pressure reading. It must be recognized, however, that, while these gauges are indicators of the pressure at the machine, they in no way indicate the pressure that exists at the nozzle. Yet the nozzle is where the work is being done; without an accurate reading of the pressure at this point, a contractor cannot know whether he has an efficient blasting operation.

There is only one way to determine the pressure at the nozzle: the use of a hypodermic needle gauge inserted into an operating sandblast hose. These gauges, available from most sandblast equipment manufacturers, are simply small dial gauges to which hypodermic needles are attached. When the needle is carefully inserted through the sandblast hose so that it sticks into the air and abrasive passage, an instant reading is obtained.

If a low pressure reading at the nozzle is registered, the following items should be checked immediately.

1. Whether or not the compressor is functioning properly.
2. The size of the air lines.
3. The size of the piping on the sandblast machine.
4. The size of the sandblast hose.
5. Whether the sandblast hose has external or internal couplings.
6. The size of the nozzle and its relationship to compressor output.

Figure 3.8 depicts a hypodermic needle gauge. The needle is inserted into the hose at the nozzle to give a true reading of the actual blasting pressure at the nozzle.

3.3.5 NONMETALLIC ABRASIVE

Silica sands have traditionally been used for nearly all open abrasive blasting operations. The material is plentiful and cheap, and good blast

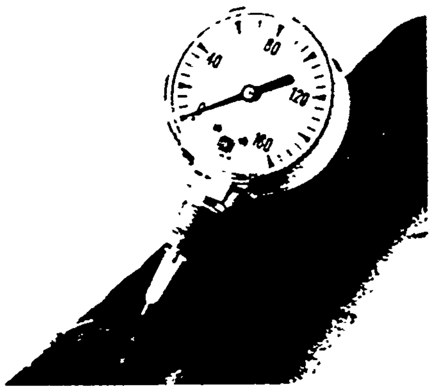


FIGURE 3.8: **Hypodermic Needle Gauge.**

rates and profiles can be obtained. Recent industrial hygiene studies, however, have discovered a high incidence of silicosis among operators, attributable to the fine dusts which are generated in the process.

Whether the correct use of safety equipment can completely eliminate this problem is somewhat of a moot question at present. Much research is presently being conducted by both OSHA and the Abrasive Producers Association to resolve this question. OSHA is presently preparing an abrasive standard; whether it will permit the use of silica sands is undetermined at this time.

Because of the silicosis controversy, many yards have begun using substitute abrasives. Probably the most readily available of these are the water-quenched slags, more commonly known as "black beauty." Reasonably good blast rates can be obtained in most applications. The material dusts excessively, being quite friable. This quality can cause problems when blasting ballast tanks and other closed areas.

3.3.5.1 Copper Slag

Copper and nickel slags are being used very effectively in Europe. The availability of these materials is limited in the United States, however.

Copper slag is a by-product of copper refining. It is crushed, sized and dried for abrasive use. The materials have the following advantages:

1. Without free silica.
2. Fast-cutting.
3. Cubic (no flats or needles).
4. Clean (nondusting).
5. Sharp and hard (MOH 6.5 – harder than feldspar, softer than quartz).
6. Able to be recycled.

A U. S. supplier claims a 50% - 60% increase in the square feet blasted per pound of material used. Tests conducted have verified this claim. The abrasives come in various sizes, affording maximum production consistent with the profile desired. 10-50, 16-50 and 20-50 grades are available. The 16-50 grade provides a 4-mils profile.

The copper slag tested is supplied by:

1. H. M. Hedrick Company
   4720 Town Plaza Drive
   Suite 101
   Houston, Texas 77036

2. H. M. Hedrick Company
   P. O. Box 14537
   Long Beach, California 90814

Figure 3.16 documents the chemical analysis of the copper slag (Apache-Blast) material.

3.3.5.2 Mineral Sand (Starblast)

Starblast is a DuPont trade name for the mineral sand produced from a naturally occurring deposit in Starke, Florida. The material is very fine, being marketed in 55, 80-and 90 mesh sizes. It has proved very useful in removing rust from master butts and in feather edging painted surfaces to be repaired. *Starblast is* also effective in sandsweeping old epoxy films to promote adhesion; because of its fineness, it does not cause loss of adhesion in the old coating. 0.4 sq. ft. of blast can be obtained per pound of material used. The material produces little dust, an advantage in closed areas. A maximum profile of 2.5 mils is obtainable.

Because *Starblast* particles are small, the material has low impact energy. It is therefore not efficient in the removal of heavy multilayer coatings and mill scale.

Information on this product can be obtained from the following manufacturer.

E. I. duPont deNemours & Company
Pigments Department
Mineral Sales
Wilmington, Delaware 19898

Figure 3.17 documents the chemical analysis of the *Starblast* (staurolite) material.

3.3.5.3 Calculation of Cleaning Costs

It is important to note that cleaning costs vary with the material (such as mill scale, rust or coatings) being removed. Different types of abrasives will prove more effective for different applications. Cleaning costs can be calculated as follows.

1. Determine, by experiment, the optimum mixture of air and abrasive. (A good point at which to start is that just before the abrasive stream becomes visible.) Generally, it is better to feed too little abrasive than too much. An over-rich mixture will actually give a lower cleaning rate (sq. ft./hr). To get maximum value, avoid poor blasting practices such as worn or incorrectly sized nozzles, insufficient air pressure, uncontrolled abrasive feed rates or other mispractices described previously in this section.
2. Using a measured amount of abrasive, clean an area of at least 100 sq. ft. and note the time required.
3. Divide the amount of abrasive used (tons) by the time required (hrs.) to get the abrasive flow rate (tons/hr).
4. Divide the area cleaned (sq. ft.) by the time required (hrs.) to get the abrasive cleaning rate (sq. ft./hr.).

The air-blast cleaning cost per square foot can then be calculated as follows.

Cleaning costs ($/sq. ft.) = $\underline{(AP + E + L)}$

where: A = Abrasive flow rate (tons/hr.)
P = Delivered price of abrasive ($/ton)
E = Equipment costs ($/hr.)
L = Labor costs ($/hr.)
R = Abrasive cleaning rate (sq. ft./hr.)
X = Adjustment factor for degree of cleaning, defined as:

White metal	**1.00**
Near-white metal	1.75
Commercial	3.70
Brush-off	8.70

3.4 Hydroblasting

The hydroblast process uses high-pressure water (4,000 - 10,000 psi), with or without abrasive, to prepare surfaces for painting. The process obviously eliminates the health hazards associated with the fine dust generated by open abrasive blasting. Thus, if blast rates equivalent to abrasive blasting could be obtained without the use of abrasive, it is obvious that cost savings would result. Unfortunately, the attainment of such rates is not the case. Even with the use of abrasive at maximum pressure, hydroblasting rates do not compare with those of open blasting. Additionally, inhibitors must be used in the water to prevent rust-blooming of the surface.

The process has gained some use in offshore repair work because of the material logistics involved. At higher pressures, however, the process becomes dangerous because of the cutting power of the high-velocity water stream.

The hydroblast process is most commonly used by repair yards, at 4,000 - 6,000 psi pressures, to remove marine growth from ship hulls. It is also used to clean tube interiors of boilers which have been in service.

One repair yard reports that 840 sq. ft./hr./man can be obtained in removing 80 mils of barnacles and marine grass from a ship's hull. Most of the original paint will remain, but it will be in a condition ready for repainting. 6,000 psi pressures and a 20° nozzle are used. If heavy barnacles are present, abrasive injection is required.

Hydroblast equipment is supplied by:

woma Corporation
P. O. Box 684
Linden, New Jersey 07036

3.4.1 CAVITATING WATER JET

The destructive power of cavitation is obvious to those who have inspected the high-cavitation areas of ship hulls which have been in service. An attempt has been made to utilize the principle of cavitation in cleaning steel. Removal of both barnacle and rust to a near-white finish was **accomplished.**

Panels were used in the test, and both in-air and submerged-surface cleaning modes were used. Fouling removal was accomplished at 2,000 psi or below, and removal of rust to a near-white finish was achieved at 6,000 psi. Initial reports of cleaning rates are promising, and studies are being continued,

The work was accomplished by Hydronautics, Incorporated of Laurel, Maryland for the Maritime Administration's National Maritime Research Center, P.O. Box 1600, Galveston, Texas. Studies are documented in the Center's report NMRC-275-42210-RI.

3.5 Sandblasting Accessories

Figures 3.9 through 3.15 present a variety of blasting accessories with some accompanying notes.

Figures 3.16 and 3.17 present chemical analysis data for two newly marketed abrasive materials.

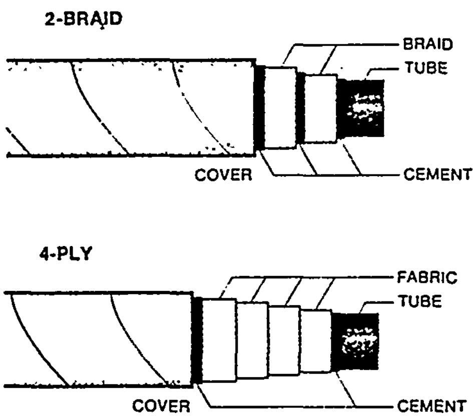


FIGURE 3.9: Blast Hoses. A blast hose must have an inner tube of natural rubber which is specially treated with carbon black to dissipate static electricity. Blast tubes are square cut and capped to prevent cover separation. Most companies provide them with inside diameters from ½" to 1-½". The hose selected should be 3 - 4 times larger than the nozzle orifice.

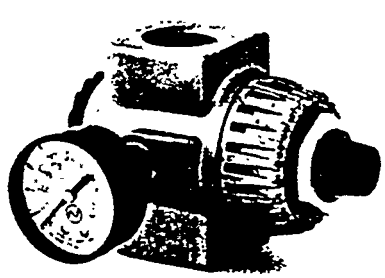
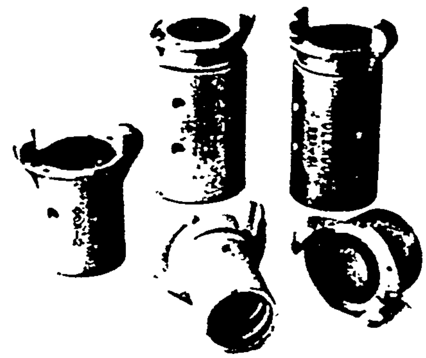


FIGURE 3.10: Pressure Regulator. Pressure regulators are used when machines are to be operated at controlled lower pressures. They are available in ½", ¾", 1" and 1-¼" sizes.



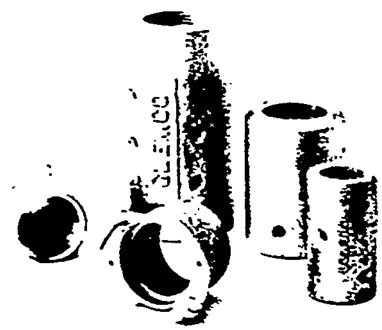


FIGURE 3.11: Couplings and Nozzle Holders. Quick couplings are externally fitted couplings which eliminate wear-producing internal turbulence. They allow quick connection and disconnection of hoses that have snap-out gaskets, assuring a perfect air seal. The nozzle holders are of lightweight aluminum and have the same quick connect-disconnect couplings.

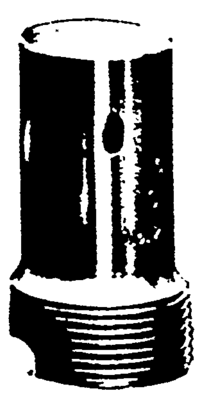


FIGURE 3.12: Angle Nozzle. Angle nozzles are designed to blast areas behind surfaces such as mold cavities or beams. They are tungsten-lined and are available with one, two or three outlets.

FIGURE 3.13: Moisture Separator. Essential in areas of high humidity, moisture separators are available in 1", 1-½" and 2" sizes, with manual or automatic drain.

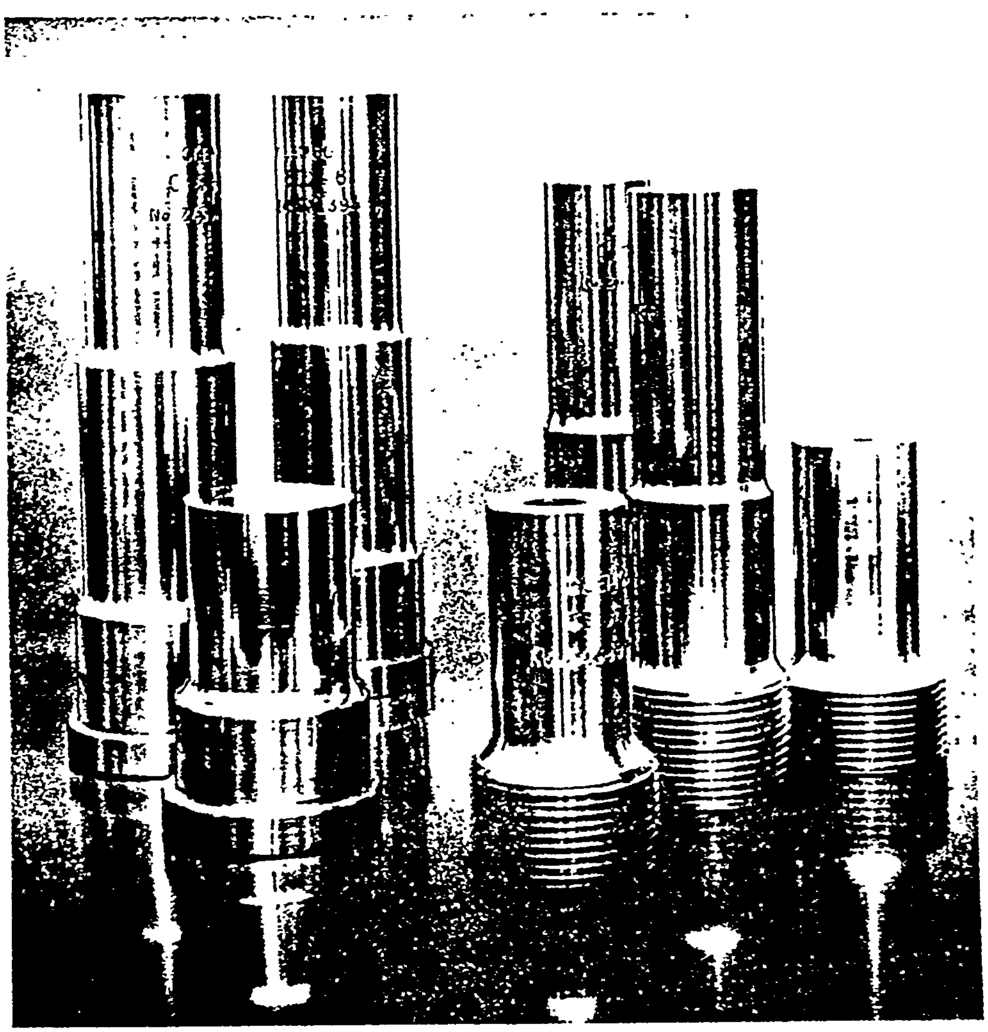


FIGURE 3.14: Venturi Nozzles.

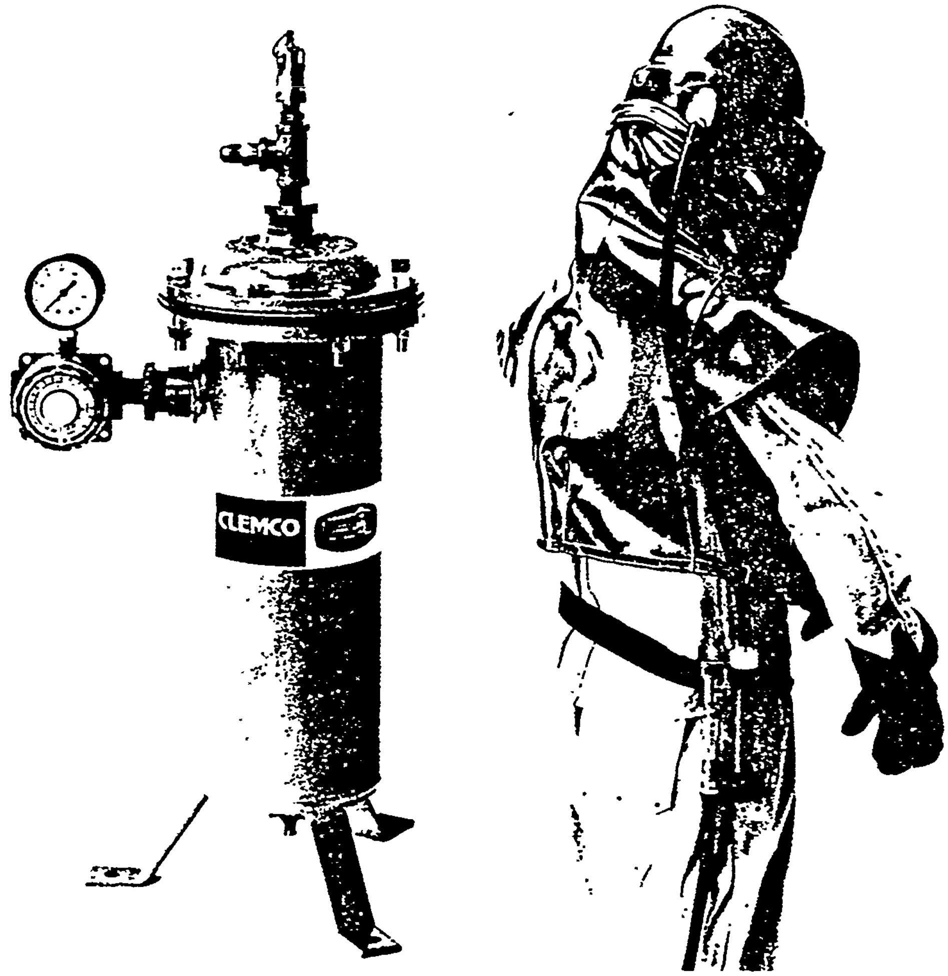


FIGURE 3.15: Blaster Safety-Comfort System. This system offers a blaster safe and comfortable gear which complies with OSHA regulations. The system consists of helmet, air conditioner, air filter and protective clothing.

Iron	41 .2% (FeO = 32.0, Fe_3O_4 = 9.2%)	Gallium	0.011
		Chromium	0.035
Silicon	38.5 (no free silica)	Nickel	0.012
Aluminum	9.41	Molybdenum	0.032
Calcium	6.1	Vanadium	0.006
Magnesium	1.51	Silver	0.0011
Zinc	1.46	Cobalt	0.015
Manganese	0.50	Strontium	0.029
Copper	0.38	Gold	0.001 (not detected, less than)
Titanium	0.18	Platinum	0.002 (not detected, less than)
Lead	0.015	Palladium	0.002 (not detected, less than)
Barium	0.027	Rhodium	0.010 (not detected, less than)
Tin	0.038	Ruthenium	0.010 (not detected, less than)

All other elements nil.

FIGURE 3.16: **Apache-Blast Abrasive–Typical Chemical Analysis.**

U.S. Standard Sieve No.	% Retained on sieve		
	Coarse	Biasill	"Starblast"
20	2	—	<1
30	3	—	<1
40	26	<1	5
50	60	8	16
70	8	26	24
100	<1	44	38
140	<1	19	14
200	<1	2	3
270	Trace	<1	<1
Pan	None	Trace	Trace
Mesh Size	55	90	80

Mineral Composition (Typical)	
Staurolite	77%
Tourmaline	10
Titanium Minerals	4
Kyanite	2
Zircon	3
Quartz	4

Chemical Composition	
Al_2O_3	45% (Minimum)
Fe_2O_3	18 (Maximum)
ZrO_2	3 (Maximum)
TiO_2	5 (Maximum)
Free Silica	5 (Maximum)

Physical Characteristics	
Bulk Density	128 $lbs./ft^3$
Specific Gravity	3.6
Hardness (MOHS)	7
Melting Point	2900°F.
Coefficient of Expansion	7.8×10^{-6}

FIGURE 3.17: Properties of Staurolite ***(Starblast).***

SECTION 4
PAINTING

4. PAINTING

4.1 General Findings

Conventional air spraying is still the predominant method of paint application in U. S. shipyards. Airless spraying is gaining wider acceptance. Smaller yards are using it in specialized applications. The larger yards. which have completed modernization programs, have widened their applications to the point where the use of airless spraying, based on gallon consumption, may be equal to or greater than the use of the more conventional system.

Roller coating is being used in specialized areas such as decks and, to a lesser degree, in the interiors of houses where overspray becomes a problem. Some repair yards have utilized it, in isolated instances, for the application of exterior hull coatings. Brush coating is used primarily for cutting in and for touch-up. Coating methods used by other industries, such as dip and electrostatic spray, have not been adapted to shipyard use.

Automatic spraying systems are used in some yards, primarily in conjunction with closed-cycle blasting for priming plates and structural. The development of a handling system for use in closed-cycle blasting of a ship's hull is being watched with interest. When such a system becomes available, it will be easily adaptable to an automatic spray head. Large savings will then be realized in hull coating, in both new and repair yards.

4.2 Airless Spray

Conventional systems utilize air for atomization; paint is carried to the surface on a current of air. Under windy conditions, the paint pattern is disturbed, resulting in loss of paint due to overspray.

With airless equipment, the paint is atomized by being forced through a small orifice at high pressures. Nothing comes out of the gun but paint, driven to the surface in a clean, fan-shaped spray. Rather than bounce off the surface the paint penetrates cracks and corners. If the spray fan is held edgewise to the wind, painting is relatively drift-free, even in a breeze.

Both methods of spray application are faster than brush or roller application, mainly because:

1. The paint supply is at hand through the gun. Continual dipping into the paint container is not required.
2. The paint is applied evenly by the spray. Slow and laborious brushing or rolling out is not required, and faster drying formulations can be used because flow-out is not as important.

4.2.1 COMPARISON WITH CONVENTIONAL SPRAY

Airless spraying is the most effective method of application commonly used in shipyards, as evidenced by data presented in Figure 4.1.

METHOD (square feet applied per 8-hour day)	
Brush	1,000 Sq. ft.
Roller	2-4,000 Sq. ft.
Air Spray	4-8,000 sq. ft.
Airless Spray	8-12,000 sq. ft.

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FIGURE 4.1: Comparison of Paint Application Methods. In addition to affording the fastest application rate, the airless method offers a further advantage. One airless coat will often give greater mil thickness than two air-sprayed coats.

Figures 4.2 and 4.3 contrast the spray patterns obtained using conventional and airless equipment manufactured by Graco.

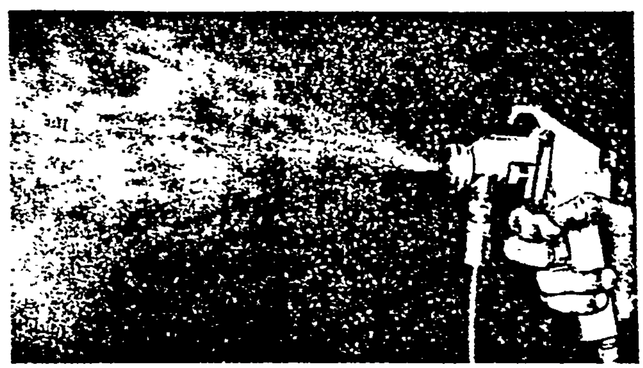


FIGURE 4.2: Air Spray Pattern.

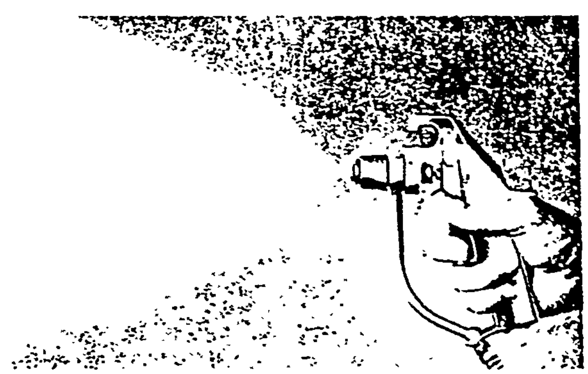


FIGURE 4.3: Airless Spray Pattern.

4.2.1.1 Advantages

The advantages of airless spray over air spray can be summarized as follows.

Speed and Ease

1. The same coverage can be obtained with an airless spray gun with far fewer passages. One airless coat often gives greater thickness than two air spray coats.
2. An airless spray gun uses a smaller compressor.
3. An airless spray gun requires only one hose.
4. No fine adjustments are required–only proper tip and paint pressure.
5. Cleanup and color change are much faster.

Quality

1. The airless method atomizes most materials in an unthinned state, thus affording greater film build per coat, as well as faster drying.
2. The force behind the airless atomized paint drives it into cracks, crevices and corners more effectively. There is less air turbulence to cause paint to bounce-back from the surface.
3. Because compressed air is not mixed with the paint, there is no danger of moisture becoming entrained in the paint film.

Economy

1. Overspray and bounce-back are reduced, resulting in paint savings.
2. Clean-cut airless spiny patterns go where they are aimed, so painters spend less time in masking and cleaning up.
3. Because no compressed air is used in atomization, the airless method consumes only one-tenth the horsepower in atomizing a gallon of paint than an air spray unit consumes. Thus a smaller, less expensive air compressor can be used with airless spray. If an electrically powered airless pump is used an air compressor is not needed at all.

4.2.2 AIRLESS SYSTEM

The components required for airless spraying are a high-pressure paint pump, a paint hose and a spray gun with an airless tip. As the method has progressed, however, refinements have been added to improve coating quality and painter convenience.

Figure 4.4 depicts the components of a modern airless system manufactured by Graco.

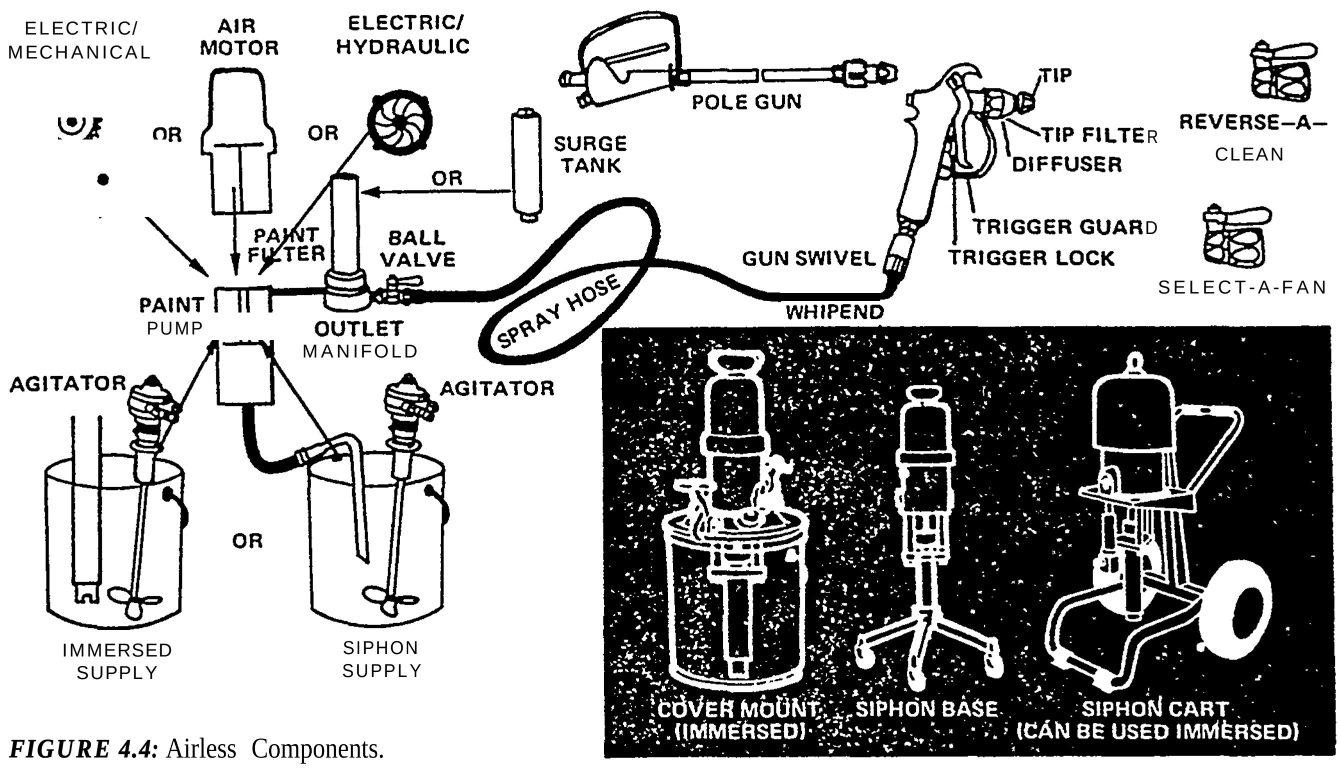


FIGURE 4.4: Airless Components.

4.2.2.1 Paint Pumps

Most paint pumps are reciprocating, positive displacement types that deliver paint under pressure on both the upstroke and the downstroke. Most models are powered by air motors, but some are powered by an electric motor via a gear train or a hydraulic motor.

Pump volume is rated in gallons per minute (gpm) and is dependent on the paint pump displacement and its number of cycles per minute.

Pump output pressure is rated in pounds per square inch (psi) and, in the case of air-powered pumps, is dependent on the ratio of the air motor piston area to the paint pump piston area and on the incoming air pressure. Thus, in a 30:1 ratio pump, 80 psi of incoming air pressure results in approximately 2,400 psi of outgoing paint pressure (30/80). In electrically powered pumps, pressure is adjustable to 2,500-3,000psi.

4.2.2.2 Pump Mountings

The various pump mountings available allow the painter to select the one best suited to his needs. Covers mount the pump directly onto 5-gallon paint pails and attach with either thumb screws or Quick-Latches. A siphon base mount is used on smooth floors, while a siphon cart mount has oversize wheels for good mobility on rough construction sites.

Pump mounting determines if a pump will be the immersed supply or the siphon supply variety. Immersed supply gives better pump priming in viscous materials, but cleanup is more difficult than with siphon supply. In that method, only the siphon tube is immersed in the paint, and it can be wiped clean easily with a rag. Siphon supply pumps can operate in pail- or drum-sized containers. An air-powered agitator is ideal for mixing paint and for maintaining the uniformity of fast-settling paints.

4.2.2.3 Outlet Manifolds

Paint leaving the pump at high pressure first passes through the outlet manifold, where it is directed to one or more spray hoses. Manifolds usually include a high-pressure paint filter; they may include a surge tank to minimize pressure fluctuation in the line. A high-pressure ball valve between the manifold and each spray hose gives individual line control.

4.2.2.4 Spray Hose

High-pressure hose carries paint to the spray gun. The longer the spray hose and the smaller its inside diameter, the more paint pressure at the spray gun is reduced. Thus, if long hoses are planned, a hose with a relatively large diameter and, perhaps, a higher pressure pump than is normally used should be selected. A 2’ small-diameter hose called a whip-end is often added between the spray hose and the gun for greater flexibility. Most units also include a 360° gun swivel for handling ease.

4.2.2.5 Spray Guns

An airless spray gun is little more than a spray tip mount and an on-off control. Safety devices include a trigger guard and trigger lock to prevent accidental discharge and a built-in diffuser to break up the high-pressure paint stream that may be triggered without a spray tip in position to atomize it. The tip filter screens oversize particles that could cause tip clogging. The final part, the spray tip, is available in more than 300 flow and fan sizes to meet job requirements. Useful tip accessories include a Reverse-A-Clean nozzle for reverse-pressure cleanout of tip obstructions and Select-A-Fan, which offers a selection of tips in two different sizes plus reverse-pressure tip cleanout. Pole guns allow a painter to spray walls and ceilings without a ladder and to paint floors and roofs without stooping.

4.2.3 ATOMIZATION

Atomization is obtained by forcing material, at high pressure, through an accurately designed small orifice in the spray cap. A combination of high velocity and the rapid expansion of the paint as it passes through the fine orifice into the atmosphere causes the stream of material to break up into a spray of fine particles.

Atomization is necessary to obtain an uniform film flow. Poor atomization results in fingers or runs and in film discontinuities.

4.2.3.1 Spray Tip Size

The atomization and control of the volume of material applied to the surface is dependent upon the spray tip size. The orifice, or hole, in the cap controls pattern size and fluid flow. Different caps are required because not all paint materials atomize similarly, due to differences in formulation, viscosity and pigment grind. A range of caps is usually necessary where a variety of paints are to be handled.

Cap orifice sizes range from under .010" to over .040”. Generally, the larger the orifice,

the greater the flow of material and, of course, the greater the speed and coverage. Coarse grind or high-viscosity material requires a larger orifice than a fine grind, light- or low-viscosity material. As a general rule, select the smallest orifice that allows the material to pass without plugging. When too large an orifice is used with thin or low-viscosity paints, the delivery of material is so fast that flooding results.

Figure 4.5 depicts a paint supplier's recommendations on the orifice sizes to be used with different generic types of coatings.

In selecting a spray cap, the angle must also be considered." The greater the angle, the wider the spray pattern. A wider spray pattern will deliver a smaller volume of material per unit area of surface or wet film thickness. When used on large, unobstructed surfaces, caps with larger angles can increase production rates, but orifice size must be increased to maintain the thickness applied.

After the proper spray cap has been selected, adjust the air pressure entering the pump to the lowest volume which will produce a full, uniform spray pattern.

4.2.4 PRESSURE

Insufficient pressure causes streaks and fingers in the spray pattern and inadequate atomization of the material. When correct operating pressure is used, the spray evens out to produce a uniform, finely atomized pattern. The pressure required to obtain this pattern is dependent upon the viscosity of the material being sprayed. The viscosity, in turn, depends on the material's temperature, and the pressure delivered by the pump depends on the ratio of the air motor piston area to the paint pump piston area, as discussed in section 4.2.2.1. All airless units develop adequate pressure to atomize average-viscosity coatings. The higher-ratio pumps are required to apply the higher-viscosity coatings, such as high-build epoxy tank coating, coal tar epoxies and polyester glass.

Figure 4.5 indicates pressures required for different types of materials.

4.2.5 PUMP VOLUME

The capacity of the pump chosen should be based on the gallons of paint sprayed per minute. This volume will depend on the number of painters operating from a pump and the tip sizes used.

Pumps are rated by how many gallons of paint they will deliver per minute (gpm) when operating at maximum recommended, or cruising, speed. Spray tips are also rated by how many gallons per minute they will pass. Thus, a pump that delivers paint faster than the tip atomizes it is properly sized. It is true that a .75 gpm pump rarely delivers .75 gal. in a minute, because of gun triggering. For the same reason, a .20 gpm tip rarely sprays .20 gal. in a minute. Nevertheless, the *relationship* between tip and pump rates is important. For example, a .021" orifice tip has a flow rate of .42 gpm and requires at least a .67 gpm pump.

It should also be noted that a .021" tip will never pass more than .42 gpm, no matter what the capacity rating of the pump supplying it. The advantage of using a pump with a higher rating than the tip is that the pump can run more slowly and therefore last longer. In addition, the pump will have a capacity reserve for use with a larger tip, more than one tip or longer **hoses.**

When using multiple tips, add the flow rates of the tips to determine what pump rate is required. For example, a .021" orifice tip has a flow rate of .42 gpm; therefore, two. such tips have a combined flow rate of .84 gpm and would require at least a 1.67 gpm volume pump.

Figure 4.6 provides data required in pump selection. Although Graco Hydra-Spray Unit data is presented, similar information is available from other suppliers.

Figure 4.5 presents a supplier's data on the volume of paint (gallons per minute) delivered by different tip sizes. If specialized tips other than those presented are used, additional information can be obtained from other suppliers.

4.2.6 INORGANIC ZINC APPLICATION

Both water base and solvent base inorganic zinc can be sprayed with specialized airless equipment. Because they are abrasive, inorganic zincs require that a very high volume at relatively low pressure be used. This procedure reduces the cycles per minute at which the pump operates, thus reducing wear. The result, with changes of materials on construction, is an efficient unit.

Some yards surveyed indicated that they are using EGD Spee-Flo Alaskan Series PZ airless equipment for inorganic zinc application. These pumps operate at a 14:1 ratio and have a capacity rating of 9 gpm. An H-gun with a .031" - .036" tip size is used. The H-gun is unique in design because pressures can be adjusted at the gun.

	Material Type	Air Cap Orifice Size	Flow Rate GPM 1600 PSI 250 Centipoise	Fluid Pressure Required (PSI)
High Visc.	Coal Tar Epoxy	.021 -.033	0.46-1.15	2500 - 3000
	Bitumins	" "	" "	" " .
Medium Viscosity	High Volume Solid Tank Coatings	.017 - .019	0.30-0.36	2000 - 2700
	High Solids Polyurethane	" "	" "	" "
	Chloronated Rubber	" "	" "	" "
	Vinyls	" "	" "	" "
	Vinyl Acrylic	" "	" "	" "
	Vinyl Coal Tar	" "	" "	" "
	Vinyl Anti-Foul	" "	" "	" "
	Zinc Rich	" "	" "	" "
	Epoxy	" "	" "	" "
	Alkyds	" "	" "	" "
Low Viscosity	Lacquers	.011 - .015	.12 - .23	1500 - 2000
	Varnish	" "	" "	" "
	Primers	" "	" "	" "
	Wash/Primer	" "	" "	" "
	Low Solids Alkyds	" "	" "	" "

FIGURE 4.5: Binks' Recommendations on Materials, Orifice Sizes, Flow Rates and Fluid Pressures. Note that pressures cited in the figure denote spraying pressures. Equipment with higher pressure output may be used to apply the material. Also note that other coating companies will supply similar data for their formulations,

Name	Power	Pressure Ratio	Delivery Up To	Cycles/ Minute	Immersed	Siphon
EM 400	¾ h.p. electric motor	2500 psi max.	.44 gpm	100		x
EH 333	1 hp. electric motor	3000 psi max.	.75 gpm	75	x	x
EH 433 GT	1½ h.p. electric motor	2700 psi max.	1.0 gpm	60	x	x
Monark	3" dia. air motor	23:1	,67 gpm	100	x	x
President	4 1/4" dia. air motor	30:1	1.67 gpm	100	x	x
Bulldog	7" dia. air motor	30:1	3 gpm	63	x	x
King	10" dia. air motor	20:1	7 gpm	50	x	x
King	10" dia. air motor	45:1	3.33 gpm	50	x	x

FIGURE 4.6: Graco Hydra-Spray Units.

4.2.7 HEATED AIRLESS EQUIPMENT

Some yards are using heated airless equipment for spraying high-build epoxy tank coatings, vinyls and other high-viscosity coatings. Numerous advantages can be derived from reducing the viscosity of the material being sprayed by heat rather than by the addition of solvents. The advantages of heated airless equipment are as follows.

1. Where ambient temperature varies from day to day, material temperatures can be kept constant by heating. Uniform viscosity and uniform spray result.
2. Many extra-viscous materials that cannot be atomized at room temperature can be sprayed when heated. Further, because no extra solvent is added, they quickly revert to their original viscosity after spraying to produce a high film build without runs or sags.
3. Because pumps operate at lower pressures to atomize heated material, they do not work as hard and thereby last longer.

Two general types of heaters are available for airless equipment: in-line systems and recirculating systems. The in-line type consists of a tubular heating unit between the pump and the gun, with no return system from the gun. Figure 4.7 depicts a recirculating type.

Heated Airless

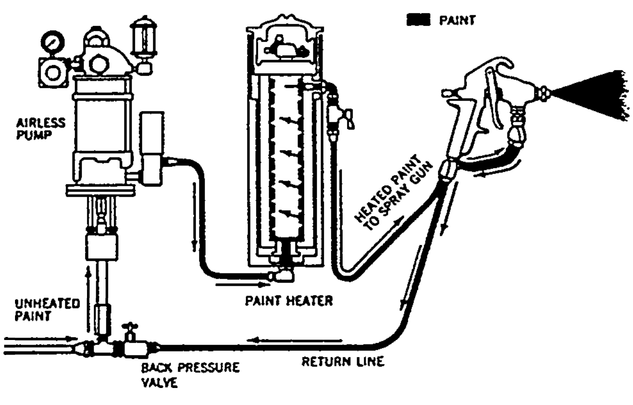


FIGURE 4.7: Recirculating Heater.

Problems have been experienced by some yards with recirculating units. The recycling of materials which are catalyzed by heat may raise the temperature of the material in the container and reduce the pot's life. It should be noted that with any type of heating, when spraying ceases for lengths of time approaching the pot life of the heated material, the heater, the line and the gun must be flushed clean with solvent.

Another problem cited for some types of recirculating equipment is air entrapment in the material.

4.3 Air Spray

Conventional air spraying from a pressure pot is still the most widely used method of paint application. Throughout decades of use, the principles have remained the same, and little innovation has occurred. Major advances have been in the improvement of equipment. The modem gun and its components are lighter in weight, longer-lasting, easier to clean and maintain and more convenient to use.

The paint gun, being an air tool, requires the same elements for efficient operation as do other power tools. The air supply is of basic importance. It must be clean, dry and of adequate pressure and volume. The air cleanliness requirements for spraying are more critical than for other air processes. Air must be completely free of oil, dirt and moisture if a quality paint job is to be performed.

Because the quality of the air supply is basic in spraying, as well as in the other operations discussed in this catalog, a critical examination should be made of the yard's air system; that is, of the compressor, dehumidifier, dispersal lines and filters.

4.3.1 AIR SPRAY SYSTEM

Compressed air performs two significant functions in conventional air spray operation:

1. Moving the coating material from the pressure pot through the fluid line to the gun at the required rate;
2. Atomizing the coating material within the spray gun.

Air and material enter the gun through separate passages and are mixed and ejected at the air nozzle in a controlled pattern. The fluid rate, or the amount of material leaving the gun, should be approximately one pint per minute. The air pressure on the material in the pressure pot (fluid, or pot, pressure) required to accomplish this will vary from 10-25 psi.

Operating pressures are important in the correct and economical application of coatings. The exact pot pressure requirement is dependent on a combination of several factors: the length and inside diameter of the fluid hose, the lift distance or height of the applicator above the pot, and the ambient temperature which affects the viscosity of the material. An excellent method for checking correct pot pressure is done by squeezing off the air hose at the gun and pulling the spray gun trigger. The unatomized material should flow out in a horizontal stream for approximately 3' and then drop off.

4.3.2 SELECTION OF COMPONENTS

Efficient, quality spraying requires, in addition to a good air supply, a selection of the correct components for material application requirements.

Figure 4.8 presents one supplier's data on the fluid nozzle size and the air consumed by the nozzle for different types of coatings. Other coating suppliers will provide air nozzle numbers and matching fluid nozzle numbers equivalent to those shown in the figure.

4.3.2.1 Fluid Nozzle

The choice of the fluid nozzle is determined by the speed of application required and the viscosity of the fluid to be sprayed. The greater the speed of application, the larger the fluid opening required. The heavier or more viscous the fluid, the larger the opening required.

4.3.2.2 Air Nozzle

The choice of the air nozzle will be determined by the type of material to be sprayed and the volume of air available for the gun. Air nozzles are made in two general categories: External Mix and Internal Mix.

The external mix nozzle, which is generally used, may be obtained in either a siphon or a pressure feed type; its operation in atomizing the fluid will be the same in either case. The external mix nozzle accomplishes atomization, as its name implies, outside of the nozzle by the action of air jets. This type of nozzle can be used with all fluids, and the spray pattern is adjustable from round to fan, with all intermediate patterns. The external mix nozzle is used for fine finishes and for most production work, as its spray pattern is not affected by wear or the buildup of dry material.

Siphon-type guns are generally equipped with a cup. Their shipyard use is restricted to refinishing, touch-up or coverage of small areas which do not require large quantities of paint.

The pressure type of external mix nozzle requires pressure to feed the material to the nozzle. The pressure may be developed by a pressure cup, a pressure tank or any of the many types of pumps. This type of nozzle is used for production work and where the quantity of fluid to be handled is large. The pressure-type nozzle has all the advantages of the siphon-type, as well as accurate control and greater range of fluid flow. Also, it is not limited to the size of the paint container, as is the siphon nozzle.

The internal mix type of nozzle accomplishes atomization by mixing the air and fluid within the air nozzle. The spray pattern of an internal mix nozzle is determined by the shape of the nozzle and cannot be changed. The advantage of this nozzle is that it requires less air to operate and produces slightly less offspray. It must be used with pressure equipment, however, and with slow drying or catalyzed materials. It is primarily used for maintenance spraying and for heavy materials where a fine finish is not required.

Figure 4.8 presents the cubic feet per minute (cfm) of air required at 50 Ibs./sq. in. of pressure for different fluid nozzle sizes. If the spraying pressure is increased, the volume of air required by the nozzle will increase. A decrease in the spraying pressure will decrease the air consumption. In selecting a nozzle, be certain that the volume of air available is sufficient to supply the gun, as well as other pieces of equipment which require air. Remember that the pressure developed by a compressor has no bearing on the volume of air required for a spray gun. As a general rule, a compressor will produce 3-5 cfm/h.p.

The volume of air used by the nozzle is the yardstick by which one may measure the speed of application, as well as the degree of atomization. The greater the air consumption, the faster the rate at which the fluid may be applied and the finer the degree to which it can be atomized.

4.3.3 VERMICULITE APPLICATION

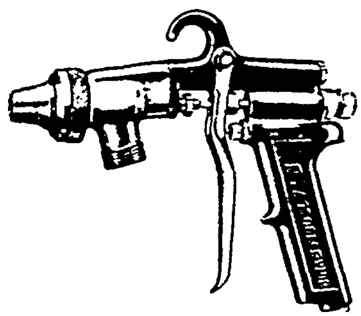
Finish specifications often require that vermiculite be applied to the paint on the internal shell plating to minimize sweating. In the past, some yards applied the paint and blew on the vermiculite while the coating was still wet.

BINKS' NOZZLE SELECTION CHART					
Type of fluid to be sprayed	Size Fluid Nozzle	@30 PSI	CFM @ 50 PSI	@70 PSI	Pattern @ 8“
Very Thin					
14-16 seconds	.040	5.1	8.7	12.2	11"
No. 2 Zahn wash	.046	9.0	14.3	20.0	14“
primers, dyes,	.070	3.4	5.0	–	9“
stains	.070	7.9	12.1	--	10.5”
Thin					
16-20 seconds	.040	5.1	8.7	12.2	11”
No. 2 Zahn	.046	9.5	14.2	19.0	15“
sealers, lacquers,	.046	9.5	15.0	20.0	13”
primers, zinc	.070	4.4	7.1		10”
chromates	.070	7.8	12.0	–	12“
Medium					
19-30 seconds	.046	9.0	14.3	20.0	14”
No. 2 Zahn	.052	9.5	15.0	20.0	13“
lacquers, synthetic	.052	4.0	6.2	9.2	9“
enamels, varnishes,	.070	8.5	15.2	19.5	13”
shellacs, fillers,					
epoxies, urethanes					
Heavy					
Over 28 seconds	.070	3.9	5.5	7.4	9“
No. 4 Ford house	.086	6.0	9.5	13.0	15”
paint, wall paint	.110	4.0	6.8	9.1	11”
(oil latex), block					
sealers, mill whites,					
vinyls, acrylics,					
epoxies					
Very Heavy					
Unaggregated	.110	6.2	9.8	13.2	15“
block fillers,	.125	3.8	6.0	9.0	12“
textured coatings	.110	9.5	14.1	19.1	12“
fire retardants					
Zinc Rich Coatings					
	.070	9.5	14.5	19.5	15“
	.070	12.0	18.0	24.0	–

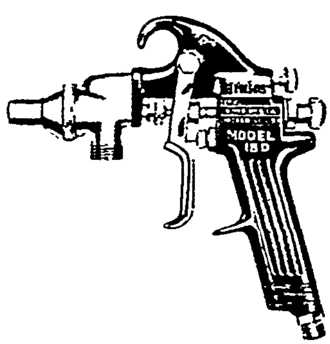
FIGURE 4.8: **Binks' Nozzle Selection Chart.** The figure shows different air consumption rates for the same fluid nozzle sizes. This variance occurs because fluid nozzles are matched with air nozzles which have different orifice sizes, producing the various fan sizes noted. The air nozzle is, of course, the factor which dictates air flow.

At present, equipment is available which allows premixing of the vermiculite in the paint prior to application. Premixing increases the efficiency and economy of the application.

The premixing equipment manufactured by Binks is depicted and described in Figure 4.9. These models are equipped with a S8 fluid nozzle or a R-30 air nozzle.

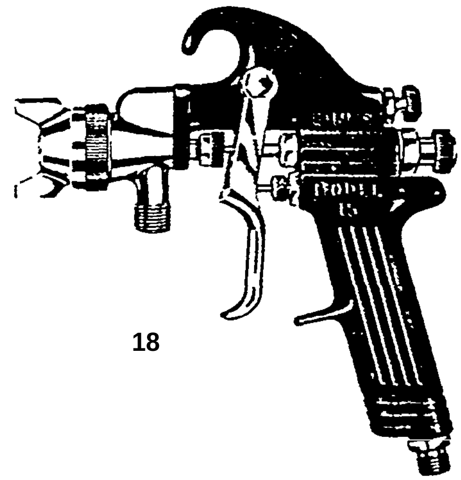


Model 7E2—
(13.2 cfm at 50 psi)
For underbody coatings and other heavy viscosity fluids. Large gun head and fluid passage for production spraying of thick fluids. Use with fluid pump or pressure tank. Air hose connection, 3/8" St P. Fluid hose connection, 3/4" St.P. Shpg. Wt. 3 1/4 lbs.



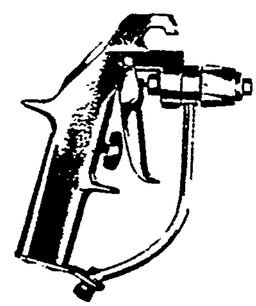
Model 18D—
(12.2 cfm at 50 psi.)
For medium viscosity fluids. Basically same as Model 7E2, but with smaller gun head. Use with fluid pump or pressure tank. Air hose connection, 1/4" St.P. Fluid hose connection, 1/2" St.P. Shpg. Wt., 3 lbs.

FIGURE 4.9: **Binks Heavy Fluid Spray Guns.**



18

FIGURE 4.10: **Binks Conventional Spray Gun,** Model 18. This gun can be used for all conventional spraying and with optional heads for corrosive, abrasive or heavy-bodied fluids. It is designed for heavyduty continuous use and affords ample control of fluid and air. It has an adjustable spray pattern, a 3/8" fluid inlet and a 1/4" air inlet. The total weight of the gun is 1 lb., 11 oz.



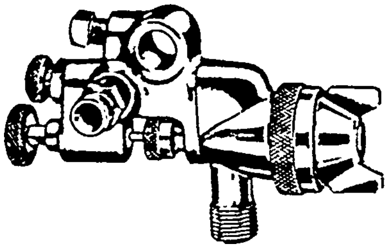
208-327

205-591

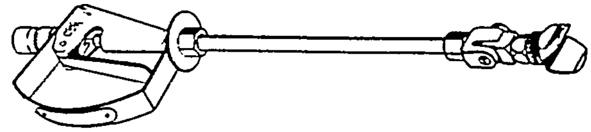
FIGURE 4.11: **Graco Airless Spray Guns. Model 208-327 is rather compact and weighs only 21 oz. It has an aluminum body, with stainless steel, teflon and carbide parts.** The working pressure is 5,000 psi. Model 205-591 **is similar and has a 3,000 psi working pressure. Both models have a 1/4" fluid inlet.**

4.3.4 PAINTING ACCESSORIES

Figure 4.10 through 4.16 present commonly encountered painting accessories and accompanying descriptive data.



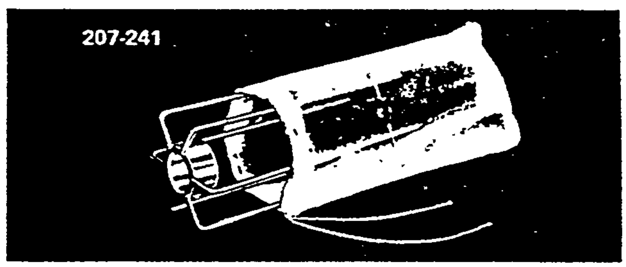
600

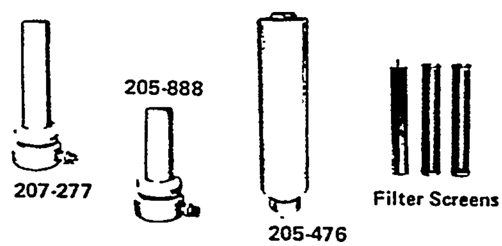


205-129

FIGURE 4.12: **Binks** Automatic Spray Gun, Model 600. This model is a standard-duty gun for continuous spray operations. It has a stainless steel fluid needle and a hardened steel or stainless steel fluid nozzle. The gun has an adjustable spray pattern, weighs 15 oz. and has a 3/8" fluid inlet and a ¼" air inlet.

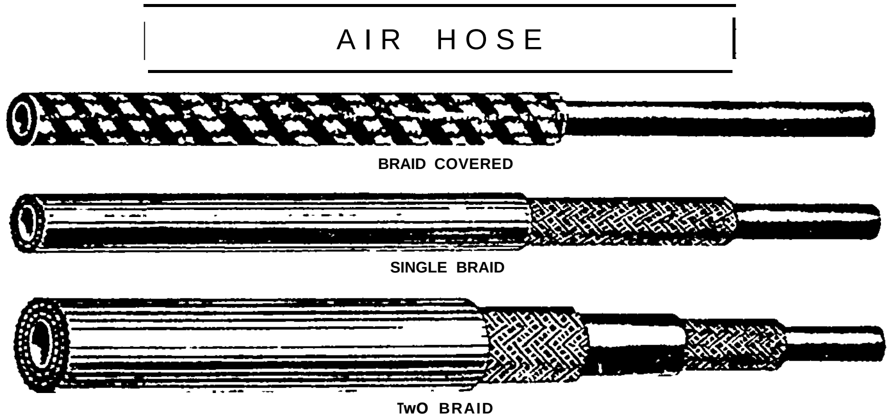
FIGURE 4.13: **Graco** Pole Gun, Model 205-129. This gun permits easy operation when spraying high or recessed areas. This particular model is 3' in length, but other models are available in 6', 8' and 10' lengths. In addition, some pole guns can be converted to different lengths by the use of extension tubes and accompanying stems.

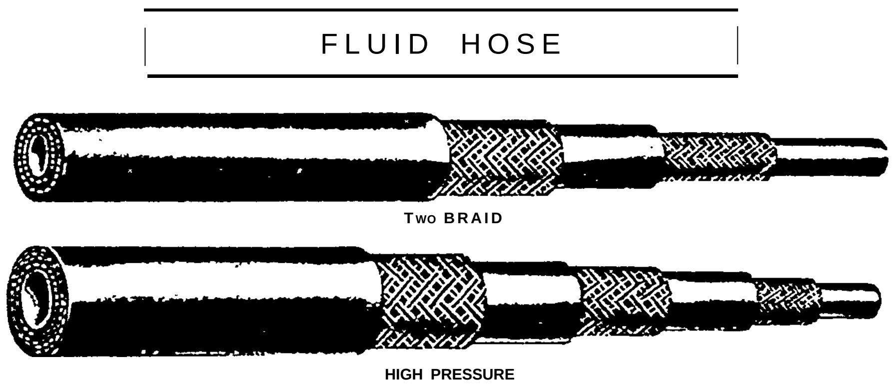




For 207-277 206-482 (18 sq. in.)	Replacement Filter Screens	For 205-888, 205-485 (7 sq. in.)
167-024	stainless steel screen, 30-mesh	167-052
167-025	stainless steel screen, 60-mesh	167-053
167-026	stainless steel screen, 100-mesh	167-054
167-027	stainless steel screen, 200-mesh	167-055
164-693	edge-type stainless steel discs, .005 in.	164-693

FIGURE 4.14: Graco Filters and Screens. Model 207-241 is a siphon tube filter that includes a support cage and a nylon filter bag. It attaches to any pail siphon tube to filter the material before it enters the pump. Models 207-277, 205-888 and 205-476 are falters that are mounted in the outlet manifold and have filter screens which catch impurities before they can clog a spray tip.



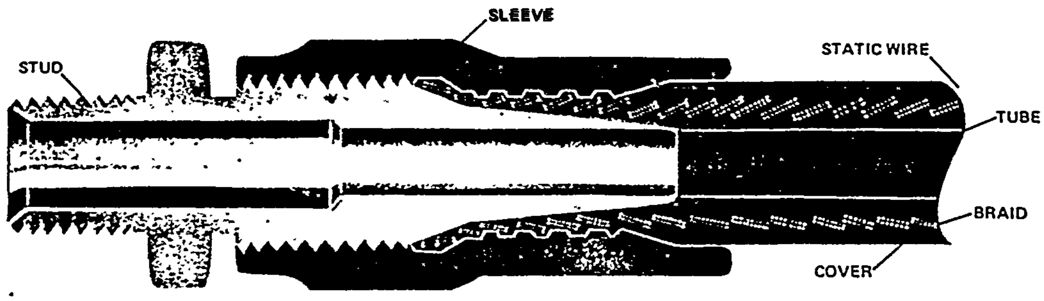


AIR HOSE DESCRIPTION	Conn. Furn. No., Size, Thread — Extractor or Tank End	Conn. Furn. No., Size, Thread — Spray Gun End
H-101. ¼" braid covered. For small spray guns. Inside diameter ¼". Outside diameter 7/16". Working pressure 80 lbs.	SC-312 ¼" St. P.	SC-312 ¼" St. P.
	SC-312 ¼" St. P.	SC-315 Angle ¼" St.P.
H-110, ¼" rubber covered, single braid. For small spray guns. Inside diameter ¼". Outside diameter ½". Working pressure 100 lbs.	SC-303 ¼" St. P.	SC-303 ¼" St. P.
	SC-310 ¼" St. P.	SC-314 Angle ¼" St.P.
H-105, 5/16" rubber covered, single braid. For production spray guns. Inside diameter 5/16". Outside diameter 41/64". Working pressure 150 lbs.	SC-317 ¼" St. P.	SC-317 ¼" St. P.
H-106, 5/16" rubber covered, two-braid. For production spray guns. Inside diameter 5/16". Outside diameter 41/64". Working pressure 175 lbs.	SC-317 ¼" St. P.	SC-317 ¼" St. P.
H-107, ⅜" rubber covered, two-braid. For production spray guns or from pressure tank to compressor. Inside diameter ⅜". Outside diameter 11/16". Working pressure 175 lbs.	SC-328 ⅜" St. P.	SC-328 ⅜" St. P.
	SC-325 ¼" St. P.	SC-325 ¼" St. P.
H-108, ½" rubber covered, two-braid. For use from pressure tank to compressor. Inside diameter ½". Outside diameter ⅞". Working pressure 175 lbs.	SC-333 ⅜" St. P.	SC-333 ⅜" St. P.
	SC-334 ½" St. P.	SC-334 ½" St. P.
H-205, ¾" rubber covered, two-braid. For use from pressure tank to compressor. Also can be used for fluid. Inside diameter ¾". Outside diameter 1¼". Working pressure 175 lbs.	SC-336 ¾" St. P.	SC-336 ¾" St. P.

FLUID HOSE DESCRIPTION	Conn. Furn. (Each End Same) No., Size, Thread
H-206, ¼" rubber covered, single braid. Inside diameter ¼". Outside diameter ½". Thiokol lining. Working pressure 150 lbs.	SC-303 ¼" St. P.
	SC-306 ⅜" St. P.
H-208, ⅜" rubber covered, two-braid, Inside diameter ⅜". Outside diameter 11/16". Thiokol lining. Working pressure 150 lbs.	SC-328 ⅜" St. P.
H-220, ⅜" rubber covered, two-braid. Inside diameter ⅜". Outside diameter 11/16". Neoprene lining. Working pressure 150 lbs.	SC-328 ⅜" St. P.
H-210, ½" rubber covered, two-braid. Inside diameter ½". Outside diameter ⅞". Thiokol lining. Working pressure 150 lbs.	SC-333 ⅜" St. P.
	SC-334 ½" St. P.
H-205, ¾" rubber covered, two-braid. Also can be used for air. Inside diameter ¾". Outside diameter 1¼". Working pressure 150 lbs.	SC-336 ¾" St. P.
HIGH PRESSURE FLUID HOSE	
H-213, ½" rubber covered high pressure hose. Inside diameter ½". Outside diameter 31/32". Working pressure 750 lbs.	SC-416 ½" St. P.
H-214, ¾" rubber covered high pressure hose. Inside diameter ¾". Outside diameter 1 9/32". Working pressure 750 lbs.	SC-417 ¾" St. P.
H-212, 1" rubber covered high pressure hose. Inside diameter 1". Outside diameter 1 9/16". Working pressure 750 lbs.	SC-418 1" St. P.

FIGURE 4.15: Binks Air and Fluid Hoses.

AIR AND FLUID HOSE



High Pressure Airless Spray Hose

Part Number	ID in.	Length ft.	Maximum Working, psi	Both Ends Coupled:
Nylon tube, urethane cover, static wire ground. 1/8 and 1/4 in. I D hoses have 1 nylon braid reinforcement. 3/8 and 1/2 in. I D hoses have 2 dacron braid reinforcement.				
206-787	1/8	2	2500	1/4 in. NPSM(F)
205-948	1/8	25	2500	1/4 in. NPSM(F) swivel
205-615	1/4	15	2500	1/4 in. NPSM(F) swivel
205492	1/4	25	2500	1/4 in. NPSM(F) swivel
205-616	1/4	50	2500	1/4 in. NPSM(F) swivel
205-776	3/8	25	2250	3/8 in. NPT(M)
205-777	3/8	50	2250	3/8 in. NPT(M)
207-090	1/2	15	2000	1/2 in. NPT(M)
205-716	1/2	25	2000	1/2 in. NPT(M)
205-774	1/2	50	2000	1/2 in. NPT(M)
Nylon tube, stainless steel cover which also serves as static wire ground.				
207-880	114	15	2500	1/4 *in.* NPSM(F) swivel
207-881	114	25	2500	1/4 in. NPSM(F) swivel
207-882	1/4	50	2500	1/4 *in.* NPSM(F) swivel
Teflon tube, stainless steel cover which also serves as static wire ground.				
205-324	1/4		2500	1/4 in. NPSM(F) swivel
205-349	1/4		2500	1/4 in. NPSM(F) swive!
204-.938	114	25	2500	1/4 in. NPSM(F) swivel
206-024	114	50	2500	1/4 in. NPSM(F) swivel

Low Pressure Air Supply Hose

Part Number	ID in.	Length ft.	Maximum Working Pressure psi	Both Ends Coupled:
Buna-N/NBR tube, Buna-N/PVC cover, 1 rayon braid reinforcement, static wire ground.				
205-418	1/2	6	200	1/2 in. NPT(M)
205-216	1/2	15	200	1/2 in. NPT(M)

FIGURE 4.16: **Graco** Hoses for Airless Spray.

SECTION 5
SUPPORT EQUIPMENT

5. SUPPORT EQUIPMENT

5.1 General Findings

Efficient surface preparation and coating operations depend as much on the use of proper support equipment–lighting, ventilation and staging-as on compliance with effective basic techniques and practices. This point could be vividly demonstrated by an attempt to blast or paint in a closed area with poor lighting and ventilation by putting on an air hood and hanging from a stringer.

This survey was limited to the smaller, more mobile types of support equipment. A program funded by the Maritime Administration on the blasting and coating of tanks, now in progress, will cover the larger ventilation, dehumidification and grit removal equipment.

5.2 Lighting

Visibility is a constant problem in abrasive blasting, due to the amounts of dust produced. To be effective, a lighting source must have great penetrating power and must cast the light directly on the area being blasted. Lights mounted on head gear and hand-held lights do not fulfill these requirements.

Light sources for painting must be explosion-proof and must be approved by the Underwriters' Laboratories for Class 1, Group D atmospheres. (Paragraph 6.2.1.2, Safety Lighting, contains further information on lighting requirements.)

A Crouse-Hinds 400-watt metal halide light bulb has been evaluated for use in tanks and has been found to do an excellent job. As the light weighs 64 lbs., its portability is somewhat limited. This problem has been minimized by mounting it on a wheel-equipped stand.

Figure 5.1 depicts the Crouse-Hinds light and stand, and Figure 5.2 provides detailed specifications.

5.3 Ventilation

Ventilation is possibly the most difficult problem encountered in the blasting and coating of tanks and closed areas. In the case of blasting, dust control is required, and efficient removal of solvent vapors is mandatory, in order to achieve a quality coating. The entrapment of solvent fumes in coatings often results in the blistering of the films and in premature failures upon ballasting of the tanks.

Air blowers of many types are used by most yards; however, the simple practice of blowing air into closed areas and the dependence on convection for exhaustion are not adequate. Egress ports with powered exhausts are essential. Unfortunately, ship designers often fail to consider these matters in their tank designs, thus creating the difficulties experienced by production personnel.

Air horns, which require compressed air, and axial electrical blowers, comprise the equipment used by most yards. If electrical blowers are used in tanks or on decks for exhausting vapors, the motors must be explosion-proof and qualified for Class 1, Group D atmospheres. Steam turbine blowers with and without heaters, are often used efficiently by gas-freeing plants, but they are rarely used in new construction because they require a steam source.

Unfortunately, each tank or closed area presents a unique problem which must be engineered on an individual basis. In most cases, tank configurations require the use of flexible ducting for efficient ventilation. Spiral-reinforced vinyl ducting is commonly used. Lightweight flexible metal ducting is also available.

The control of blasting dusts also represents a problem which can only be solved on an individual basis. Any exhaust system used must incorporate a dust collection capability which meets OSHA requirements.

Figures 5.3 and 5.4 depict and describe typical blowers currently in use. The following companies supply similar equipment.

1. Coppus Engineering
   344 Park Avenue
   Worcester, Massachusetts 01613
2. Joy Manufacturing Company
   338 South Broadway
   P. O. Box 431
   New Philadelphia, Ohio 44663
3. Buffalo Forge Company
   3900 Wisconsin Avenue
   Suite S 495
   Washington, D. C. 20016
4. ILG
   639 South Scott Street
   Room 206
   New Orleans, Louisiana 70119
5. Hartzell
   Piqua, Ohio 45356

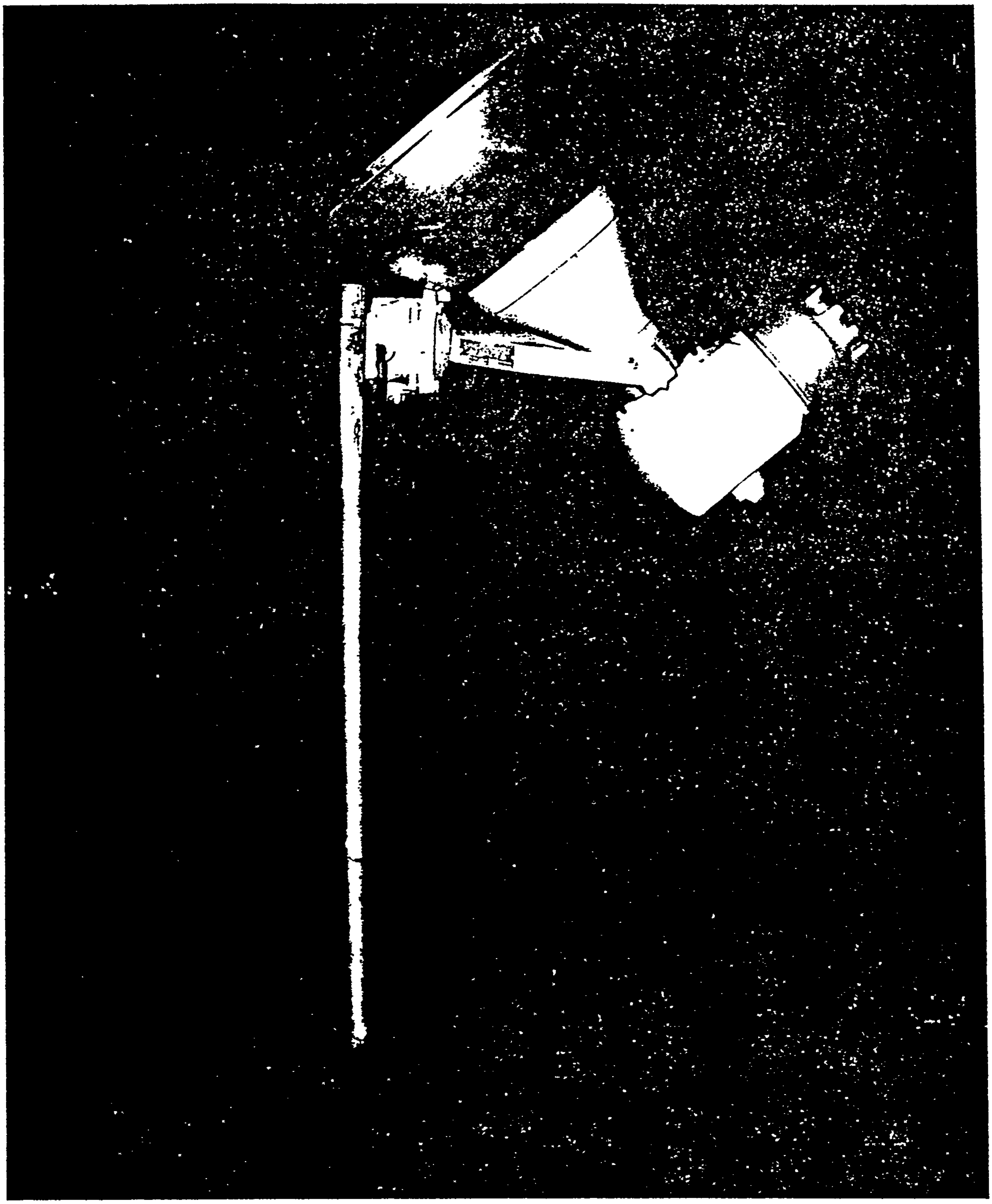
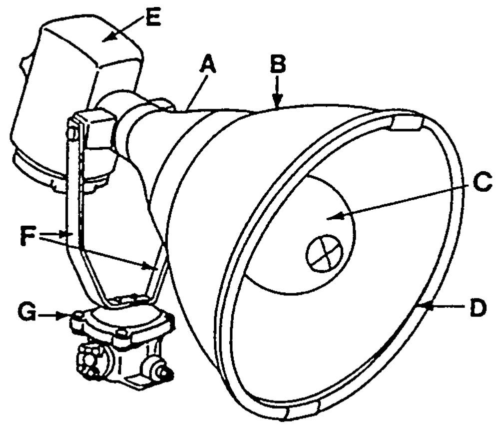


FIGURE 5.1: Crouse-Hinds Explosion-Proof Floodlight.



Effective Projected Area: 2.1 sq. ft.

EHID CONSTRUCTION FEATURES

A. Cast **aluminum lamp housing.**
B. Alzak aluminum reflector (choice of two beam **spreads).**
C. Inner heat and impact-resistant glass globe.
D. Closed unit has enclosure door with stainless **steel latches and impact-resistant glass lens.**
E. Integrally wired ballast and housing.
F. Support pipe and trunnion arm. Pipe provides wiring feed from floodlight to junction base.
G. Mounting base and junction box for mounting on flat surfaces. Four, 3/8''-diameter mounting holes spaced 2-22/32" x 5-3/8". Two holes for 3/4" pipe feed. When base is mounted on horizontal surface the unit can be aimed a maximum of 45° down.

ORDERING INFORMATION

Lamp Type	**Description**	**Medium Beam Reflector**	**Wide Beam Reflector**	Net Weight (lbs.)
Mercury Vapor 175 Watt	Open Unit **Closed Unit**	EHID-M-1HCW2* EHID-MC-1HCW2*	EHID-W-1HCW2* EHID-WC-1HCW2*	45 **52**
Mercury Vapor 250 Watt	Open Unit **Closed Unit**	EHID-M-2HCW2* EHID-MC-2HCW2*	EHID-W-2HCW2* EHID-WC-2HCW2*	**47** **54**
Mercury Vapor 400 Watt	Open Unit Closed Unit	EHID-M-4HCW2* EHID-MC-4HCW2*	EHID-W-4HCW2* EHID-WC-4HCW2*	**50** **57**
Metal Halide 400 Watt	Open Unit Closed Unit	EHID-M-4MHP2* EHID-MC-4MHP2*	EHID-W-4MHP2" EHID-WC-4MHP2*	**57** **64**

• Indicates ballast voltage (high power factor, regulated output). Change this digit in accordance with ballast voltage desired: 2 = 120V, O = 208V, 4= 240V, 7 = 277V and 8 = 480V. Some models available with 50 hertz ballasts.

PHOTOMETRIC DATA (for estimating purposes)

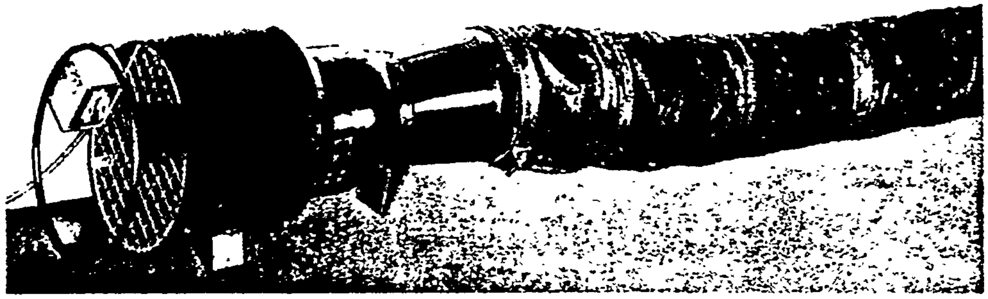
Lamp **Watts,** Type	**Lumens Vert.**	Reflector	IES– NEMA Flood Type Her. x Vert.	**Beam Spread** Hor.*x Vert.*	**Beam** Lumens*	Eff.	**Maximum Candle-** Power"	**Catalog Number**
400 w, **coated**	*23000*	**Medium**	6 x 6	121 x 122	**11800**	**51.3**	7769	EHID.MC-4HCW2
[illegible] **vapor**	**23000**	**Wide**	7 x 7	141 X 142	12350	53.7	4139	EHID-WC-4HCW2
400W, clear	34000	**Medium**	6 x 6	118x119	**17914**	**52.7**	**11459**	EHID-MC-4MHP2
metal halide	*34000*	Wide	7 x 7	140 x 140	18942	55.7	6105	EHID-WC4MHP2

● **For open units multiply values by 1.1. Data based on floodlights tested in accordance with I ES procedures. Additional data (including 175/250 mercury vapor units) available on request.**

FIGURE 5.2: Crouse-Hinds Explosion-Proof Floodlight Details. The EHID is an explosion-proof floodlight utilizing 175/250/400 watt mercury vapor or 400-watt metal halide lamps. It can be used for a variety of applications in Class 1, Group C and D locations. These locations include oil refineries, oil and gasoline loading docks, aircraft servicing areas, paint manufacturing plants and pumping stations, etc. The 175-watt and 250-watt units can be used in either the Group C or Group D locations. The 400-watt unit can be used in Class 1, Group D locations only.

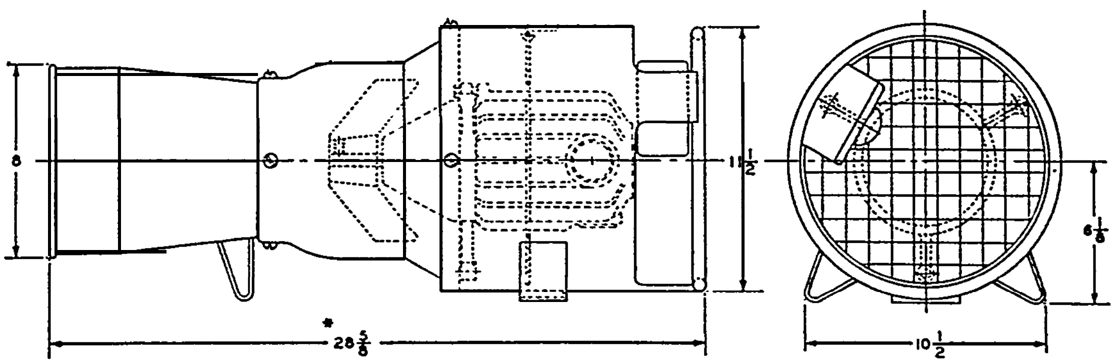
The unit has a cast aluminum lamp housing, Alzakaluminum reflector (choice of two beam spreads), heat and impact-resistant glass globe, integrally wired ballast and housing, support pipe and trunnion arm. The support pipe provides wiring feed from the fixture to junction box base. Closed unit keeps the reflector cleaner and has an enclosure door with stainless steel hinges and heat and impact-resistant glass lens.

Units must be aimned below horizontal, only.



DATA

Size	Motor	CFM	Net Weight
175	½ h.p.	1500	74 lbs.



*On the explosion-proof type, this dimension is 311/2".

FIGURE 5.3: Coppus Ventilator-Blower. The Vano Design "B" Ventilator is designed to discharge air or fumes from confined compartments such as double bottoms in ship construction, tanks, drums, etc. It may also be used as a blower to supply fresh air to such confined places, either with or without tubing attached to the ventilator outlet.

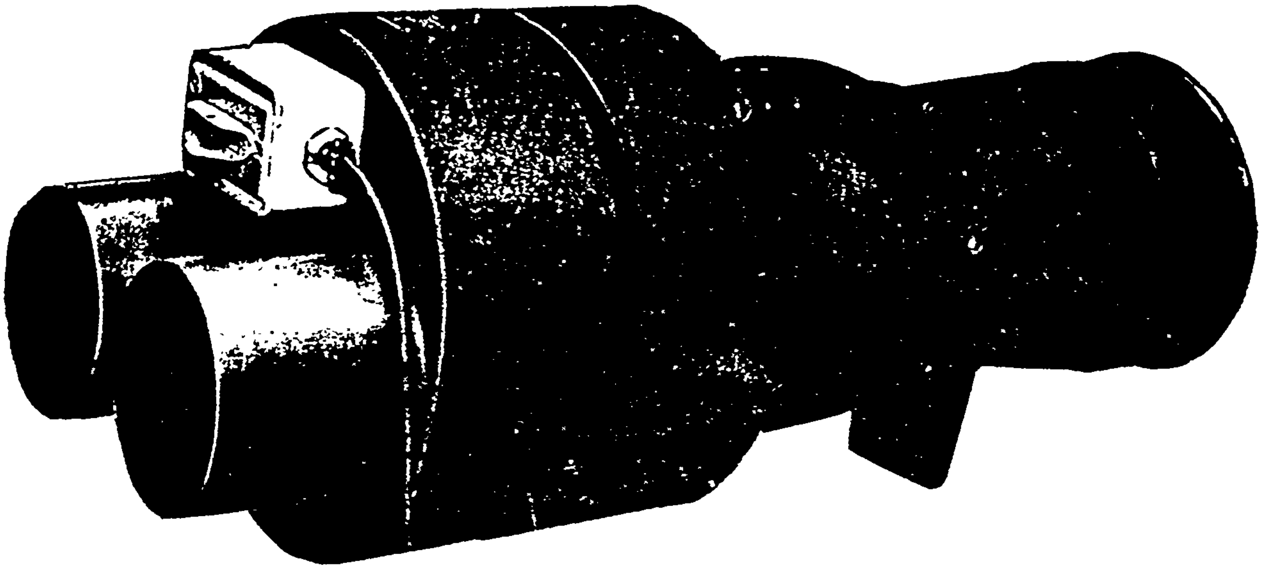
This unit may be operated in any position. Short supporting feet permit operation in horizontal position, and the sturdy inlet ring allows setting up in vertical position drawing the air or fumes from the lowest point. Its compact construction permits it to pass through an opening as small as 14" in diameter.

This type is popular with aircraft manufacturers for purposes of supplying fresh air into wings, fuselages, etc. and for stirring up air in cargo planes, to make working conditions more comfortable.

Motor: The ½ h.p. motor is a specially designed G.E. Universal type, grease-sealed, ball-bearing construction, with cast aluminum housing, available for 110-volt and 220-volt current, but not for dual voltage. Can be operated on AC, single phase, 25 to 60 cycles, and on DC. Totally- enclosed construction is standard. Explosion-proof type for use in hazardous locations, Class 1, Group D also available.

Accessories: Starting switch and 12-ft. cord with plug are standard. (Explosion-proof motor includes explosion-proof starting switch, but no cord or plug.)

Tubing: 8"-diameter flexible canvas tubing is easily attached to the ventilator outlet. Tubing is furnished in 10-foot sections, with a clamp for attaching the first section to the ventilator outlet, and coupling rings for connecting additional sections.



DATA

Size 175	Motor ½ h.p.	CFM See Capacity Table	Net Weight 79 lbs.

CAPACITY TABLE

Suction Nozzle Diameter	Number of Nozzles	CFM Per Nozzle					
		Length of Hose					
		10 ft.	20 ft.	30 ft.	40 ft.	50 ft.	100 ft.
8"	1	**1400**	**1300**	**1230**	**1180**	**1120**	**900**
5"	2	625	575	490	430	400	–
4"	3	400	330	**290**	**260**	–	
3"	4	**240**	**185**				

FIGURE 5.4: Coppus Ventilator-Exhauster. The Vano Design "C" Ventilator is ideal for withdrawing welding fumes from confined places or directly from the welding rod.

It can be furnished with 8" suction inlet to which may be attached 8" non-collapsible suction tubing. . .or it is provided with multiple inlet nozzles for 5", 4" and 3" suction hose. The discharge may be connected to 8" tubing.

Motor: The ½ h.p. motor is a specially designed G.E. Universal type, grease-sealed, ball-bearing construction, with cast aluminum housing, available for 110-volt and 220-volt current, but not for dual voltage. Can be operated on AC, single phase, 25 to 60 cycles, and on DC. Totally-enclosed construction is standard. Explosion-proof type for use in hazardous locations, Class 1, Group D, also available.

Accessories Starting switch and 12-ft. cord with plug are standard. (Explosion-proof motor includes explosion-proof starting switch, but no cord or plug.)

5.4 Grit Removal

Grit removal is one of the costly operations associated with open abrasive blasting, whether in enclosed tanks or from exterior hulls. Because EPA requirements prohibit the discharging of abrasive materials in waterways, expensive clean-up of dry docks is required. This process is in many yards with brooms, shovels, buckets and similar implements. Some yards have realized the costs involved, however, and are now using the heavyduty vacuum cleaners very effectively.

These vacuum machines pick up shot, grit and debris and transfer it to distant areas through long hoses. The dust is removed by filters and the air is returned to the atmosphere, dust-free. Hose lengths run up to approximately 500', and diameters run from 2.5" to 6". The design of these machines requires that they operate on a large volume of air. Hence, they are more efficient, if the smaller lines are operated from a manifold, which can be vented to atmosphere, if all hoses are not operating. The machines, having vacuum capabilities of up to 20" of mercury, are very efficient in abrasive removal.

Figure 5.5 depicts a typical heavy-duty vacuum cleaner manufactured by NFE International, Ltd.

The following companies offer vacuum units of various sizes.

1. NFE International, Ltd.
   413 West University Drive
   Arlington Heights, Illinois 60004
2. D. P. Way Corporation
   P. O. Box 6336
   3822 West Elm Street
   Milwaukee, Wisconsin 53209
3. Central Engineering Company, Inc.
   4429 West State Street
   Milwaukee, Wisconsin 53208

5.5 Respiratory Protection Equipment

There are three classes of respiratory protection devices: (1) air purifying devices, (2) supplied air devices and (3) self-contained breathing apparatus.

Air purifying devices remove contaminants from the atmosphere. They can only be used in atmospheres containing sufficient oxygen to sustain life (at least 16% by volume at sea level) and within the specified concentration limits of the specific device. Various chemicals remove specific gases and vapors, and mechanical filters remove particulate matter. The basic types of air purifying devices are mechanical-filter respirators, chemical-cartridge respirators and the combination of mechanical-filter and chemical-cartridge respirators.

Supplied air devices deliver breathing air through a supply hose connected to the wearer's facepiece. It is imperative that the air delivered be free of contaminants. The air source must be located in clean air and monitored frequently. With the exception of hose masks with blowers, these devices should be used only in atmospheres which are not immediately dangerous to life. The basic types of supplied air devices are air line respirators, with constant flow or demand flow. and hose masks, with or without blowers.

Self contained breathing apparatus provides complete breathing protection for various periods of time, based on the amount of breathing air or oxygen supplied and the breathing demand of the wearer. The basic types of self-contained breathing apparatus are the oxygen cylinder rebreathing, the chemical oxygen rebreathing (self-generating), and the demand types.

Self-contained breathing apparatus are not commonly used in abrasive blasting or painting but are restricted to emergency use in areas of low oxygen or toxic fumes.

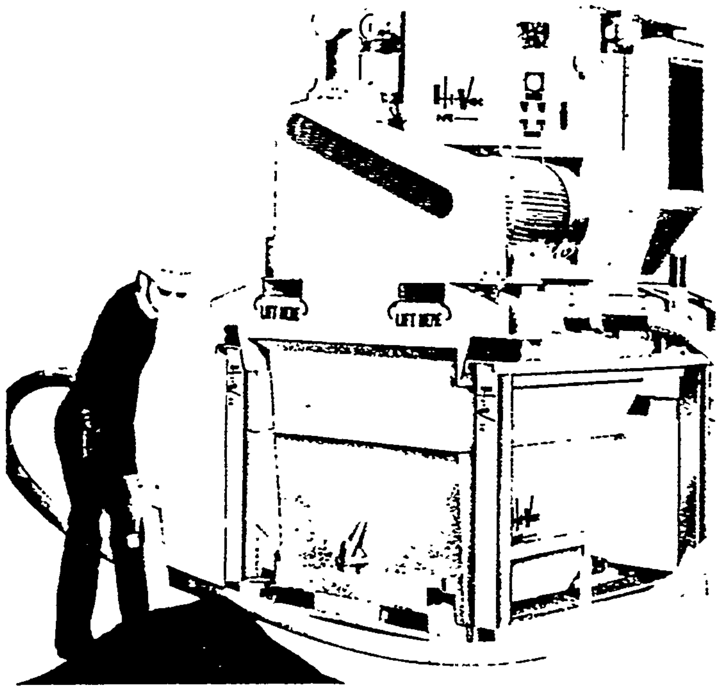
5.5.1 AIR PURIFYING TYPES

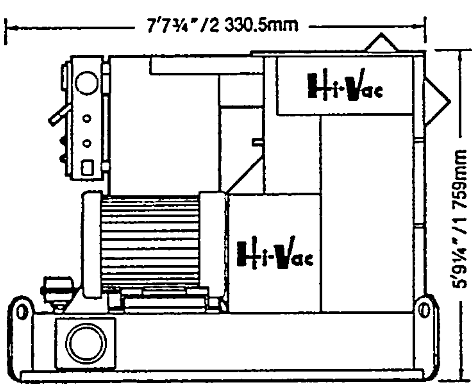
Many respirators feature twin-filter cartridges which have large areas and capacities for low breathing resistance and long service life. Each cartridge is color-coded to enable easy identification of the particular hazards against which each cartridge offers protection. There are three aerosol-type and six chemical-type respirators which are approved under 30 CFR (Code of Federal Regulations), Part II.

The following is a list of some of the companies that produce OSHA-approved respirator equipment.

1. Mine Safety Appliances Company
2. American Optical Company
3. General Scientific Equipment Company
4. Willson

Figure 5.6 depicts a typical cartridge-type respirator mask.

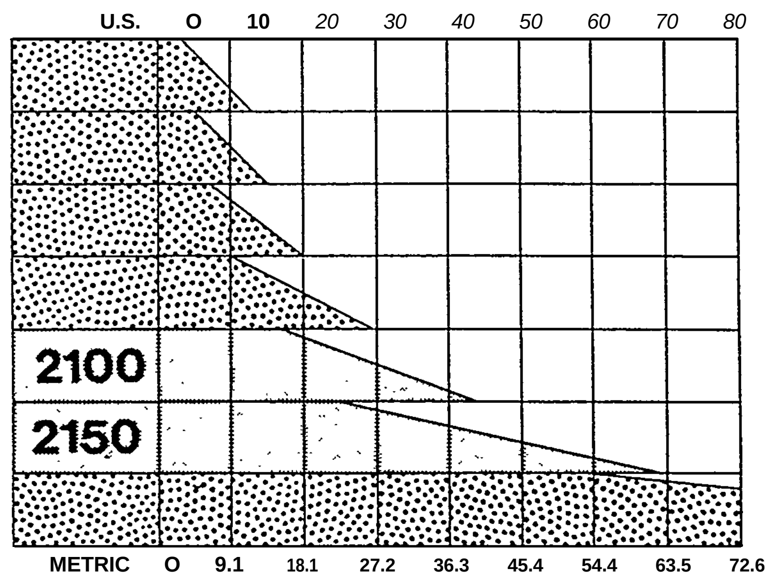




width: 7'4¼"/2 241.6mm

Hoppers deslgned to customer specifications.

CAPACITIES IN TONS PER HOUR*



MODEL 2100	Us.			METRIC		
Capacity in Tons/Hour*	16-45			14.5 -40.8		
Conveying Pipe Inside Diameters	5"	6"	8"	127 mm	152mm	203 mm
Nominal Conveying Distances	*300'*	*350'*	*400'*	91 m	107 m	122m
Horsepower	Ica			101.4 (75 kw)		
Maximum Suction	18" of mercury			457 mm Hg		
Electrical Requirements	To customer specifications			To customer specifications		

FIGURE 5.5: NFE International Vacuum Cleaner.

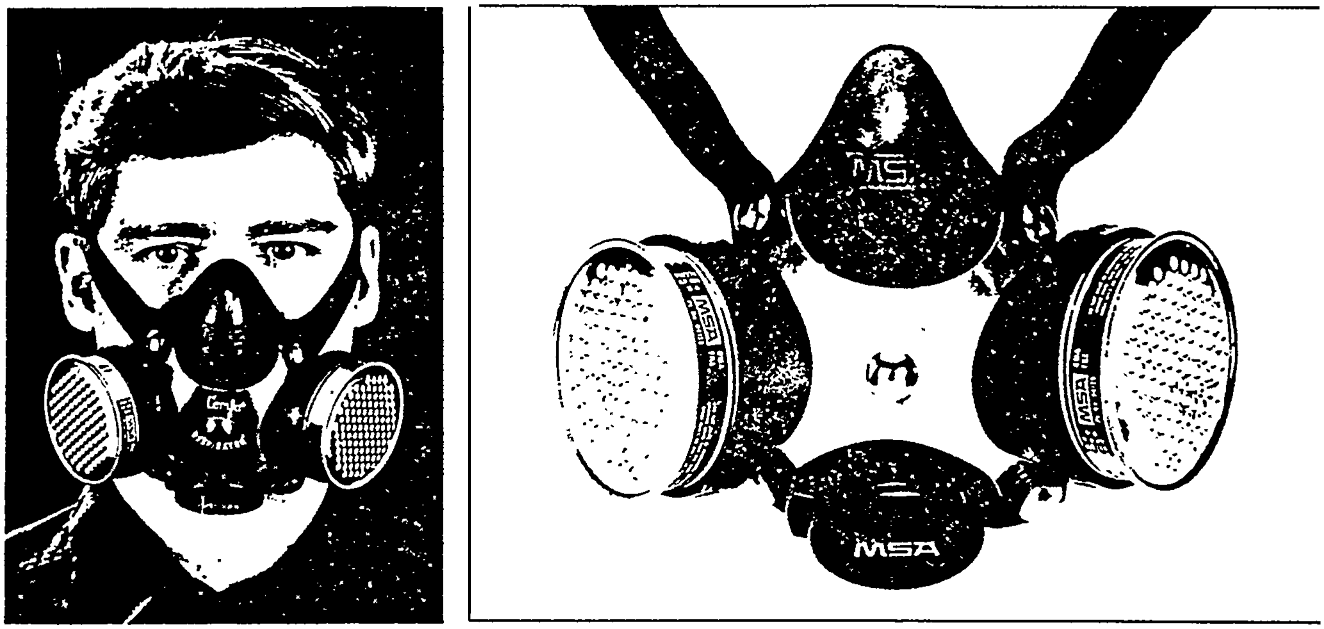


FIGURE 5.6 Cartridge-Type Respirator Mask.

5.5.2 TYPICAL AIR LINE HOOKUP FOR RESPIRATOR HOOD OR HELMET

A typical air line hookup is shown in Figure 5.7. The system has a mainline air purifier to remove moisture, pipe scale, vapors and dust from pressure lines. It also has a unit purifier which is similar to the mainline purifier but much smaller. It is an auxiliary purifier which traps the moisture and grit that can build up in systems where there is a considerable distance between the mainline purifier and the air outlet.

The pressure relief valve, pressure regulator and gauge, air flow control valve, quick-connect coupling and air purifiers are shown in Figure 5.8. The air line couplings are incompatible with outlets for other gas systems to prevent the inadvertent servicing of air line respirators with nonrespirable gases or oxygen.

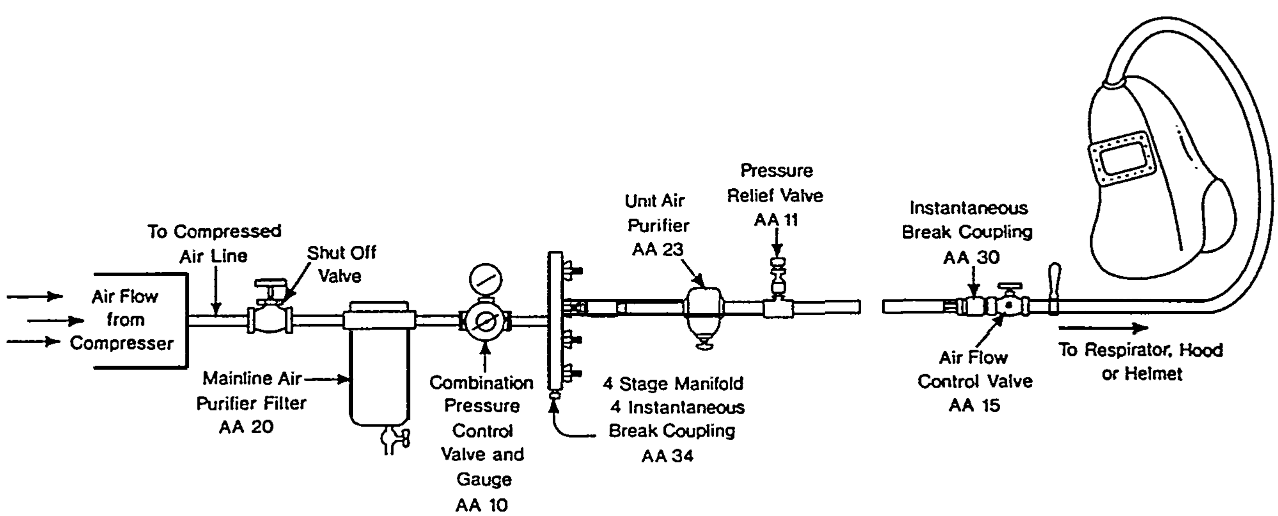
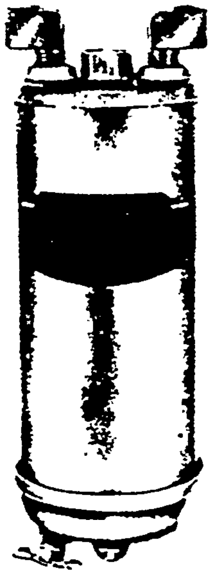
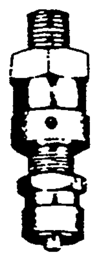


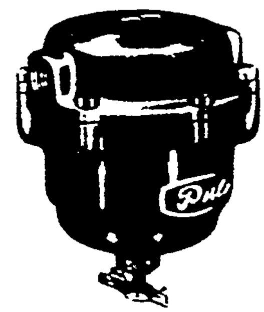
FIGURE 5.7: Typical Air Line Hookup for Respirator.



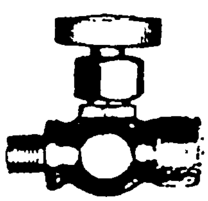
AA-20 Mainline
Air Purifier Filter



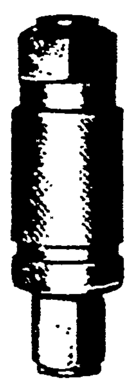
AA-11 Pressure
Relief Valve



AA-23 Unit Purifier



AA-15 Air Flow
Control Valve



AA-30 Quick-
Connect Coupling

AA-1 O Pressure
Regulator and Gauge

FIGURE 5.8: General Scientific Air Line Accessories.

SECTION 6
OSHA IMPACT

6. OSHA IMPACT

6.1 Organization

The Occupational Safety and Health Administration (OSHA) is an organization which produces the set of standards, conditions, methods, operations and processes necessary to provide safe and healthful employment and places of employment- The National Institute for Occupational Safety and Health (NIOSH) of the U. S. Department of Health, Education and Welfare (HEW) has, within its Division of Technical Services, five branches which contribute at various stages to the overall program. One of these branches tests such items as safety equipment, assigning a number to each item approved.

Shipyards must comply with the standards and requirements of these agencies. Although they are numerous and complex, it appears that most of their conditions are being met by the shipyards.

The rules and regulations governing abrasive tools are clearcut. Tool manufacturers supply tools which are in compliance with these requirements, and users, in most cases, are doing their share in following rules and regulations. The greatest single impact of these regulatory agencies has probably been in the area of blasting. Blasting operations are rapidly changing in order to provide a cleaner environment. More blasting is being done in enclosed areas, and closed-cycle blasting will probably be used much more extensively in the future.

6.2 Regulations

Requirements of the Occupational Safety and Health Standards are often difficult to interpret because they consist of both horizontal or general standards, which apply to all industries, and vertical standards, which apply to a particular industry, such as the maritime industry.

Unfortunately, the horizontal and vertical standards are often inconsistent. The general standards are more stringent, in some areas, than the specific industry standards. Thus, even though a company may be complying with the maritime standards, the local or regional OSHA director may deem it necessary to enforce the more stringent horizontal standards. Inconsistency in the application of standards on a regional basis further complicates interpretation and compliance.

The vertical standard, governing maritime employment usually takes precedence over the horizontal standard. However, if an obvious conflict exists, it is advisable to request clarification from the local or regional OSHA office.

6.2.1 MARITIME EMPLOYMENT

OSHA'S regulations for shipyards are detailed in its publication, *Maritime Emnployment*, Safety and Health Regulations, Parts 1915 to 1919. Part 1915 applies to repair, and Part 1916 applies to new ship construction. These regulations are the basic standards for ship construction; they encompass the standards for surface preparation.

6.2.1.1 Respirators

New NIOSH respirator equipment standards were enacted on January 11, 1976. Equipment purchased prior to this date may not meet these requirements, although some older models can be upgraded to the new standards by modification. Care should be exercised in purchasing new equipment to insure that it meets the latest requirements. All NIOSH-qualified respirators should bear a certification test (TC) number.

6.2.1.2 Safety Lighting

Parts 1916.24(4) and 1915.24(7) of the *Maritime Employment* standards apply, to safety lighting in hazardous areas, for new construction and repair areas respectively.

These paragraphs state that light shall be approved by the Underwriter's Laboratory for use in Class 1, Group D atmospheres. This classification does not restrict the voltage used. In contrast, paragraph 1926.401(4) of the standard for the construction industry restricts lighting to 12 volts in similarly closed hazardous areas.

This discrepancy provides a good illustration of how a conflict of standards can affect actual practices. Higher wattage mercury vapor bulbs may be used, in approved, explosion-proof lights, in tanks and other closed areas aboard ships. The result is a much improved illumination system. Some lighting suppliers are not cognizant of this difference in standards, however; they may try to sell 12-volt systems for these applications. It may thus be advisable for individual shipyards to clarify requirements with the OSHA office for their particular zone.